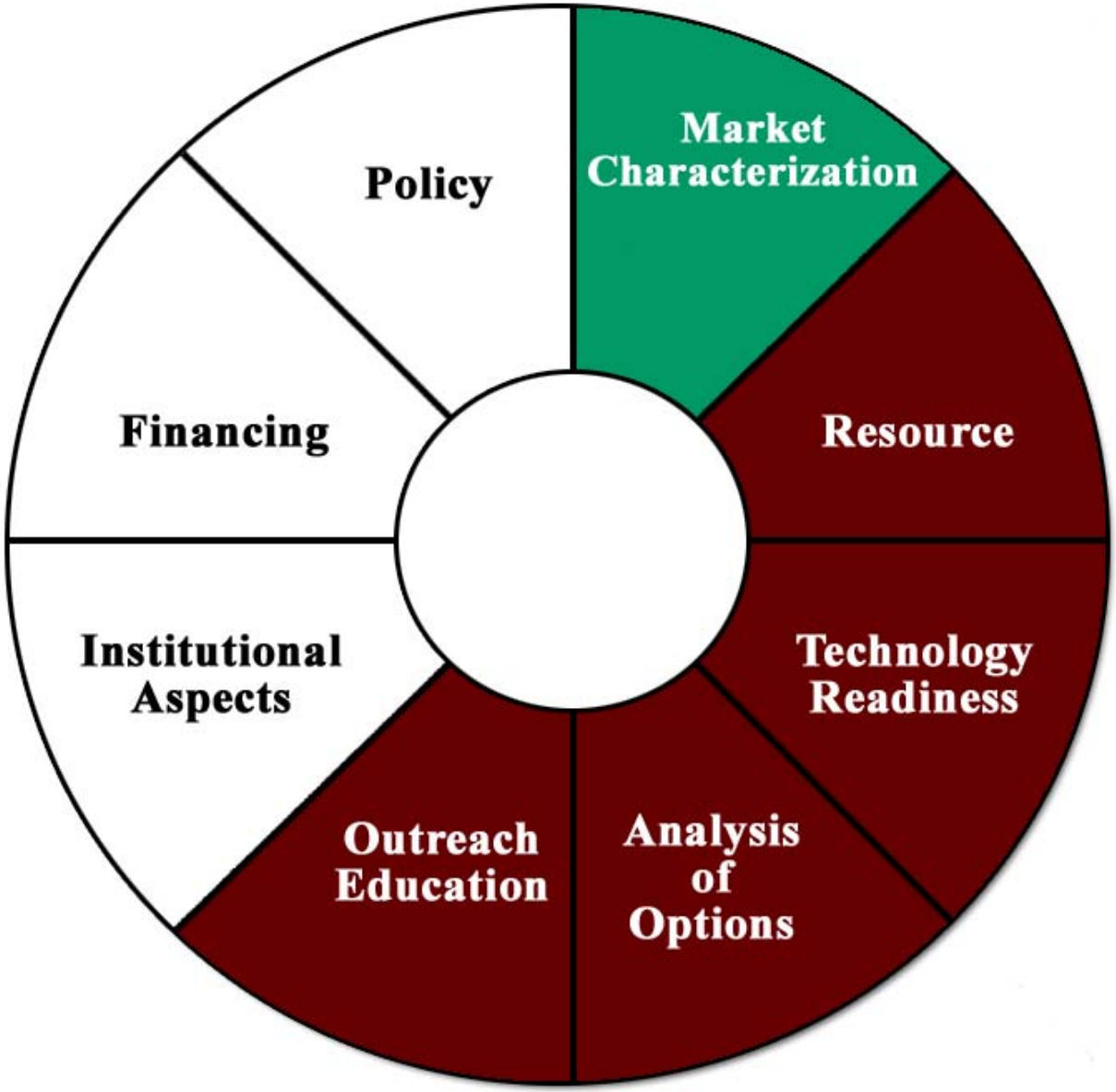
Wind Water Nexus

Larry Flowers

FY05 DOE Wind Implementation Meeting

November 17, 2004

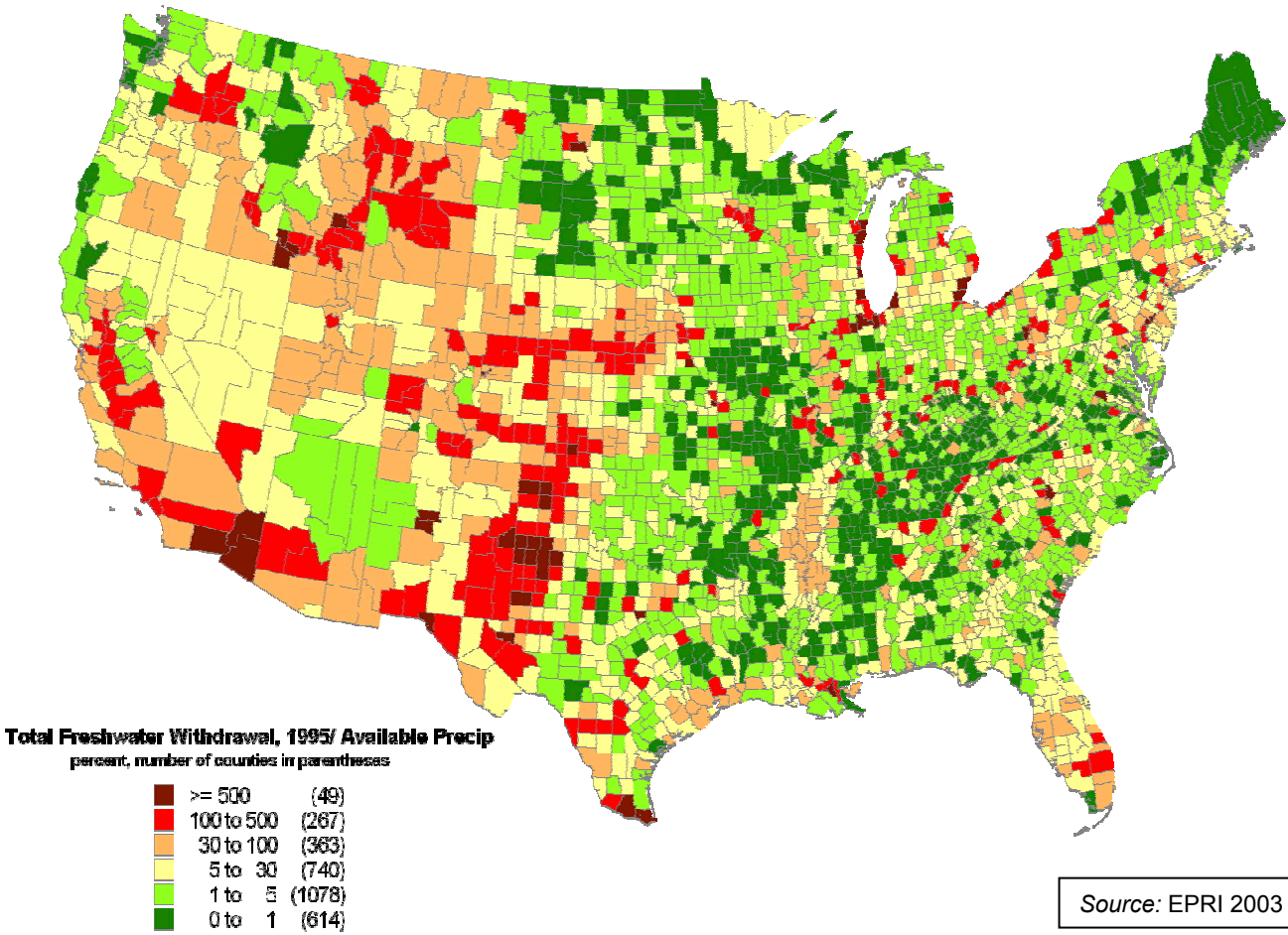
Application Wheel



Total Water Withdrawals, 2000

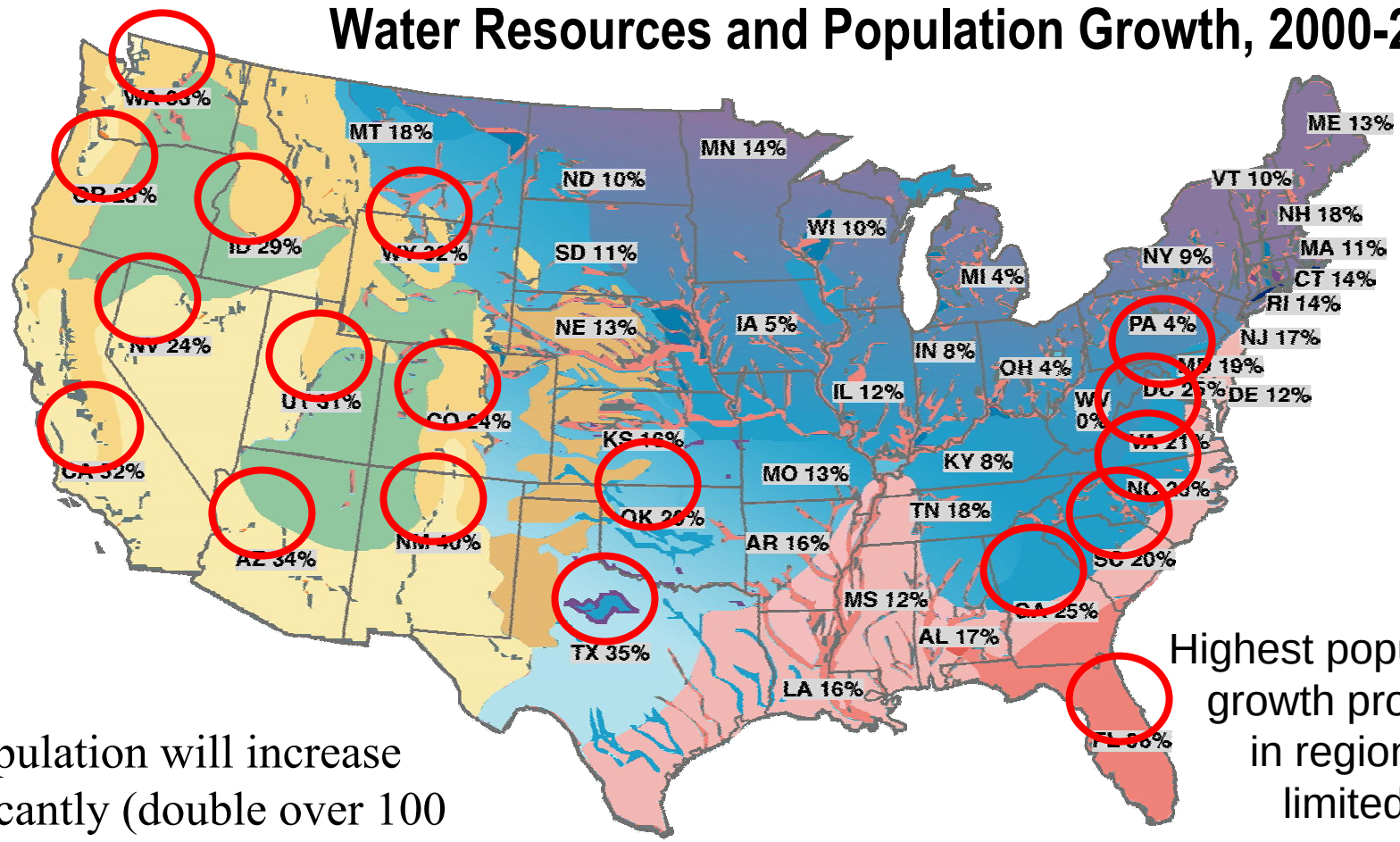
Source: **USGS Circular 1268, 15 figures, 14 tables** (released March 2004 and revised April and May 2004).Available at: http://water.usgs.gov/pubs/circ/2004/circ1268/index.html

Sustainable Withdrawal Of Freshwater Is National Issue



Source: EPRI 2003

Conflicts between economic development and water availability will continue across the US



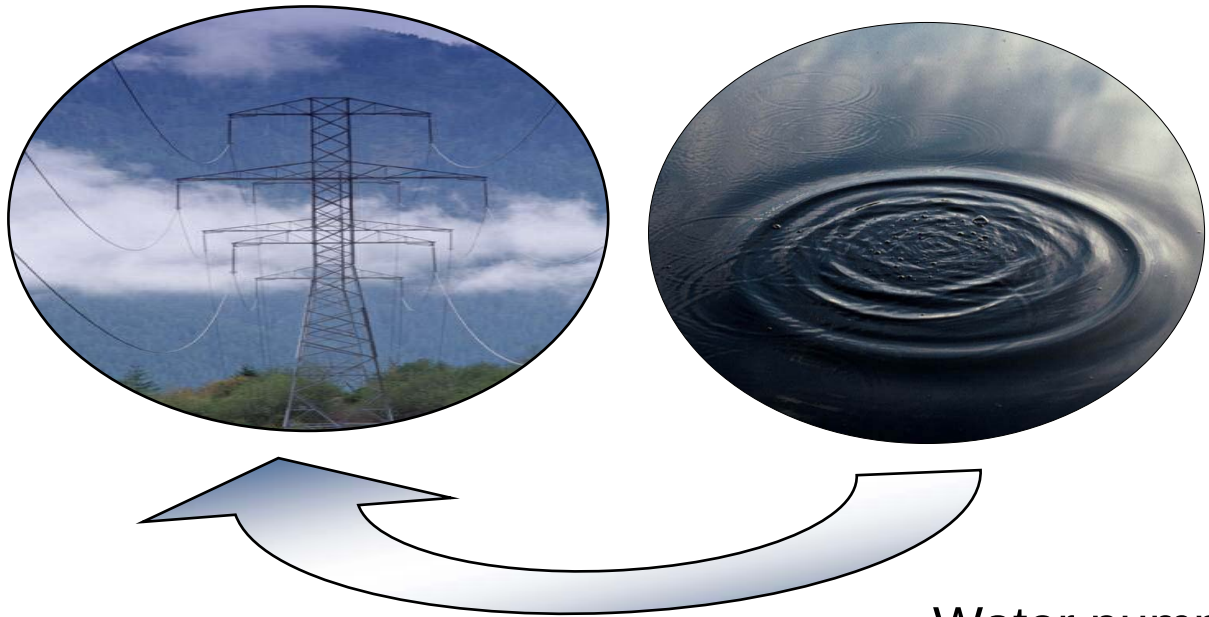
US population will increase significantly (double over 100 years)

Highest population growth projected in regions with limited water resources

Source: DOE/NETL (M. Chan, July 2002)

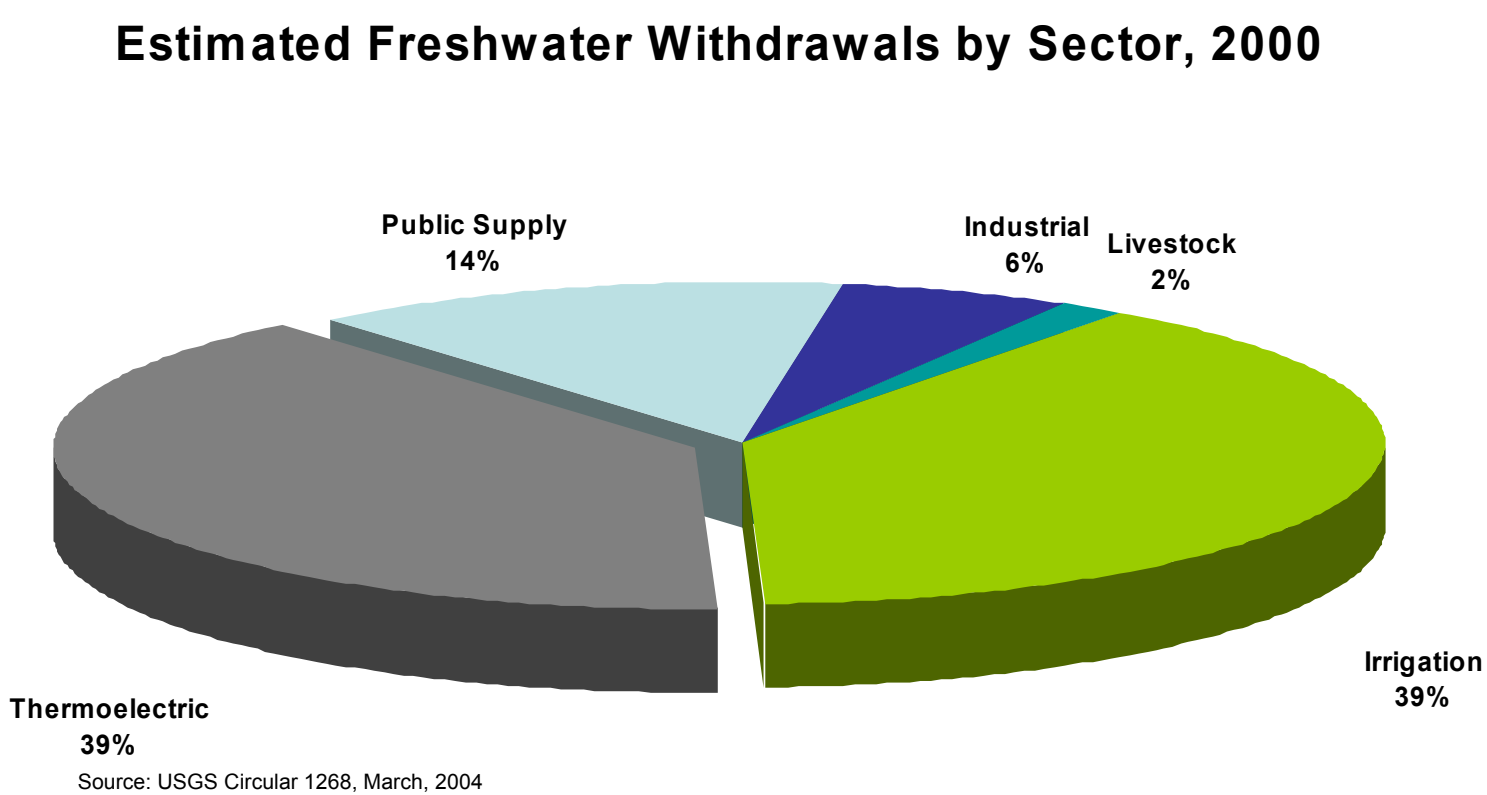
Energy and Water are Inextricably Linked

Energy production and generation require water



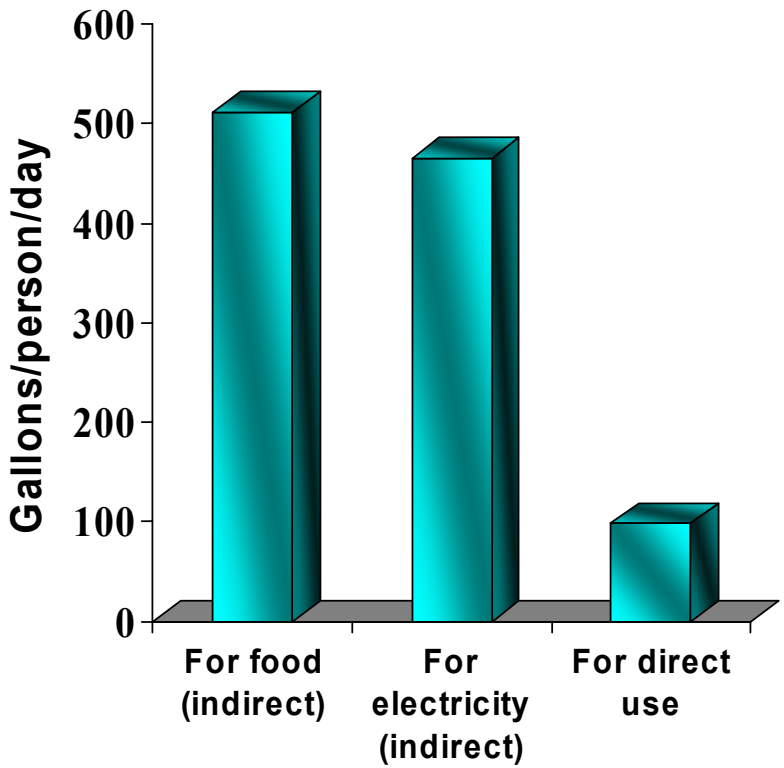
Water pumping, treatment, and distribution require energy

As Much Freshwater Is Used For Producing Electricity As For Irrigation



Energy Requires Water

Water required to produce household electricity exceeds direct household water use

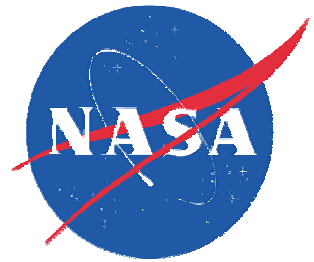


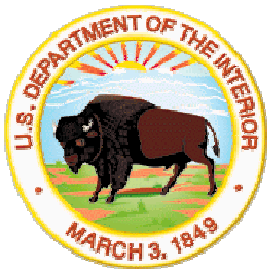
GALLONS PER PERSON PER DAY

- 510 for food production
  - includes irrigation and livestock
- 465 to produce household electricity
  - Range: 30 to 600 depending on technology
- 100 direct household use
  - includes bathing, laundry, lawn watering, etc.

Source: from Gleick, P., World's Water 2002-2003, 2002

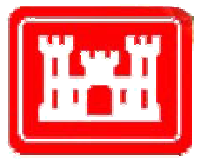
Many Federal Agencies Address Water, But Not at the Energy~Water Nexus



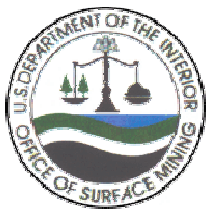


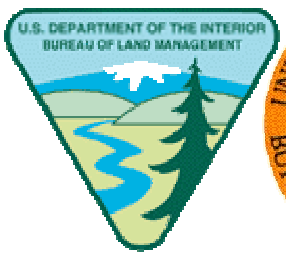
No one is responsible for:

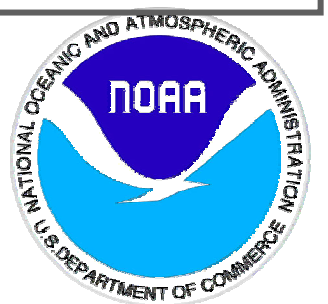
- **Water related impacts on energy policy**
- **Water used by energy production**
- **Energy used by water systems**



US Army Corps of Engineers®







Energy Security is Threatened at the Energy~Water Nexus

- Water is a limited resource
- Sustainable withdrawal of freshwater is a national issue
- Energy and water are inextricably linked
- Science and Technology can help resolve challenges at the energy~water nexus
- Action is needed now

THE ENERGY~WATER NEXUS

a strategy for energy and water security

Argonne National Laboratory
Operated by the University of Chicago

Berkeley Lab

Brookhaven National Laboratory

INEEL

Los Alamos National Laboratory

NETL National Energy Technology Laboratory

NREL

ornl Oak Ridge National Laboratory

Pacific Northwest National Laboratory

Sandia National Laboratories

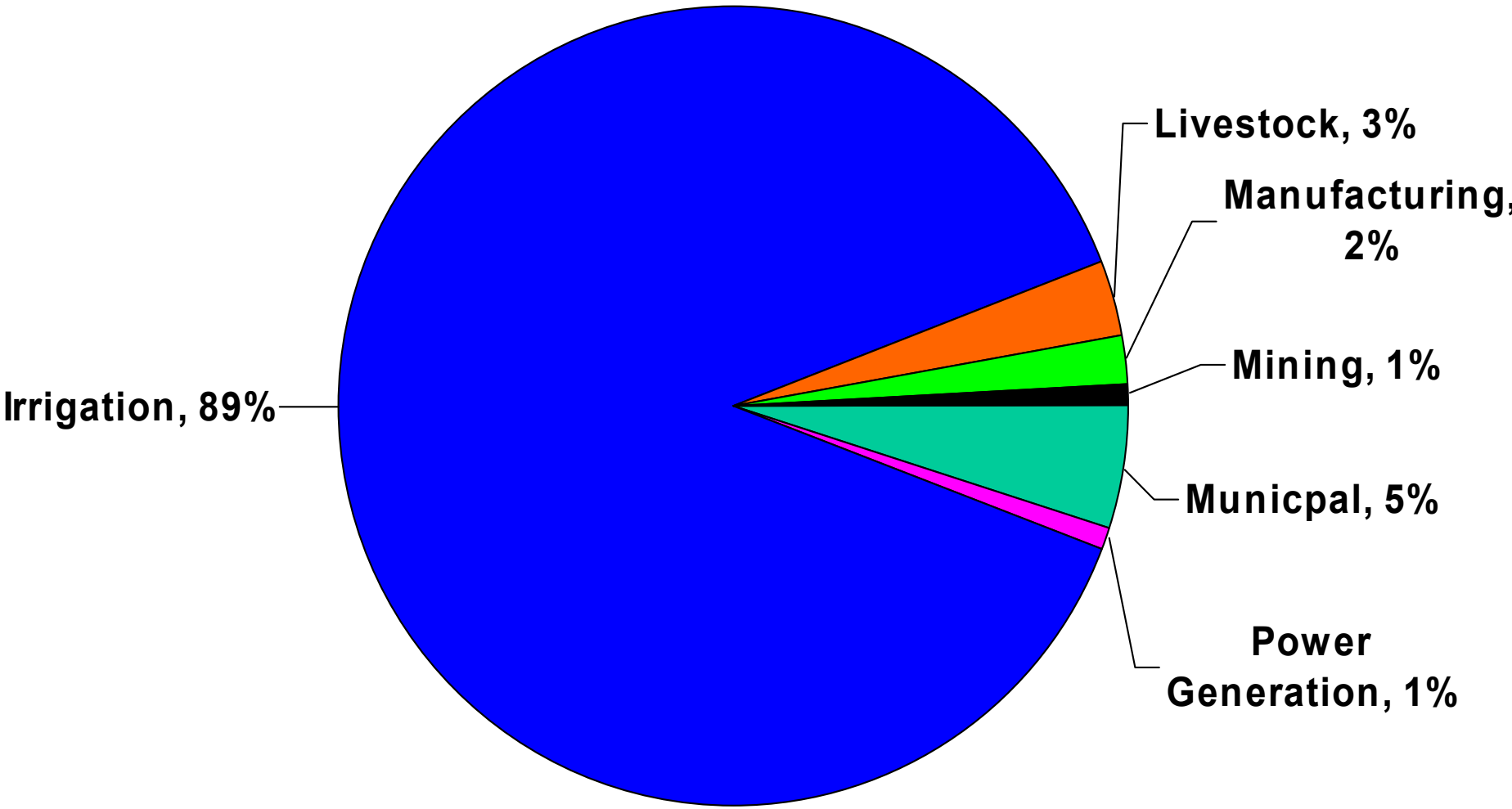
Points to Cover

1. Municipal Water-Energy Nexus
   Energy Intensity of Water, and
   Water Intensity of Energy
2. Six Research Questions
3. Methods, Data, and Challenges
4. Preliminary Findings
5. Thoughts for Next Steps

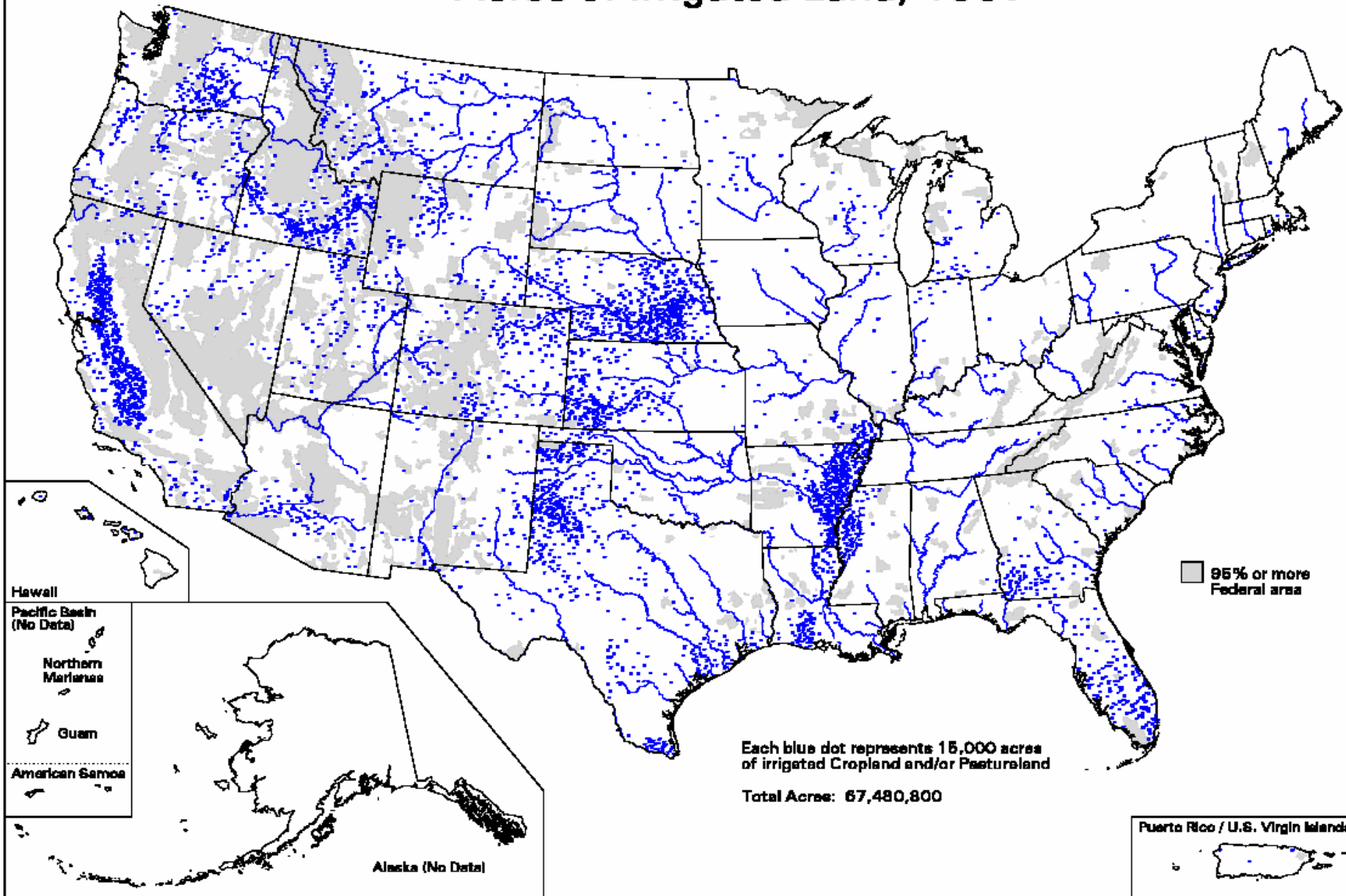
Irrigation

R. Nolan Clark
USDA-Agricultural Research Service
Bushland, TX

Water Use for 2000



Acres of Irrigated Land, 1997

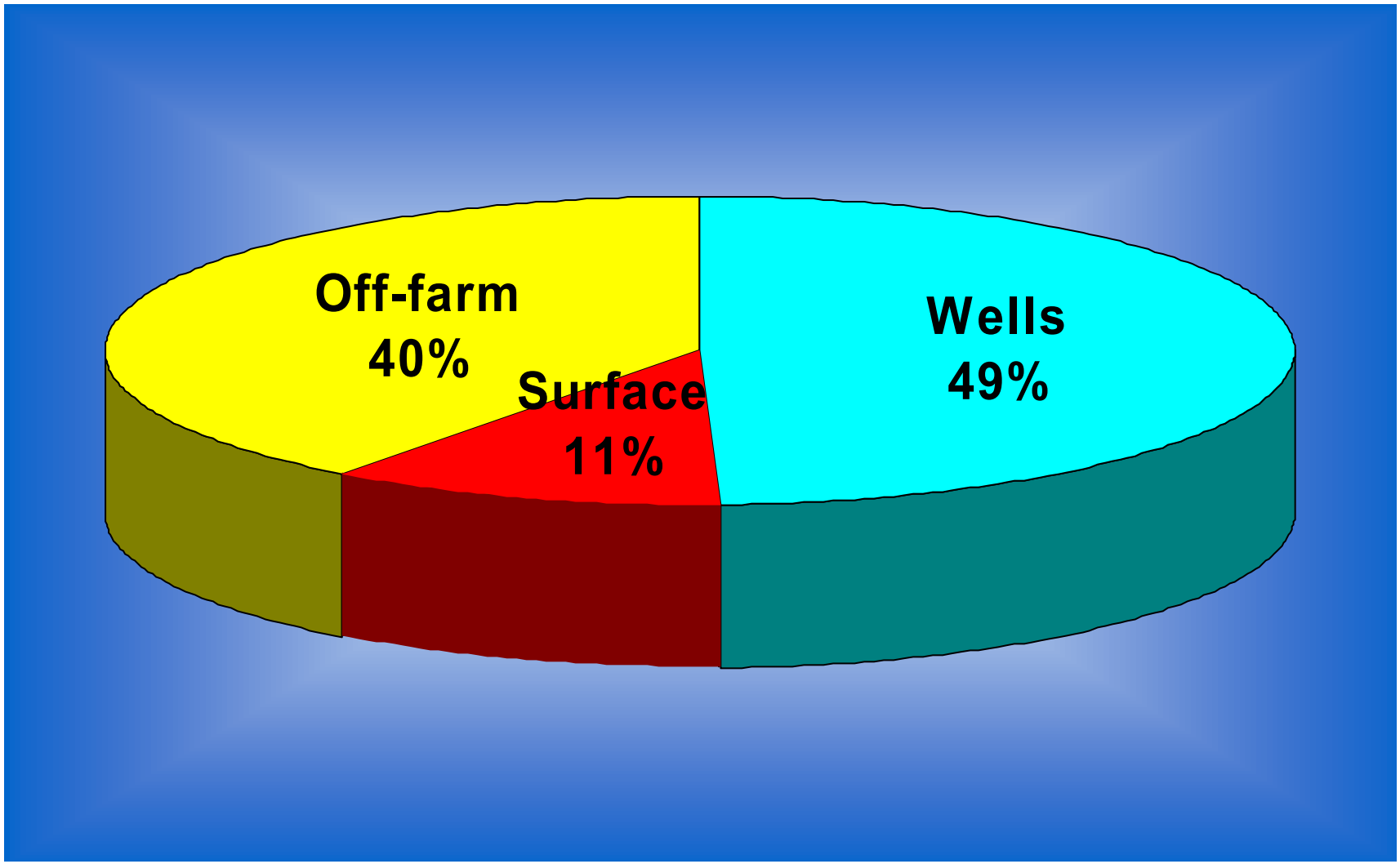


USDA NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service
Resource Assessment Division
Washington DC January 2001

Map ID: m5297
For proper interpretation, see Explanation of Analysis for this map at our web site. Search for "USDASOTL" to locate our map index.

Data Source: 1997 National Resources Inventory
Revised December 2000

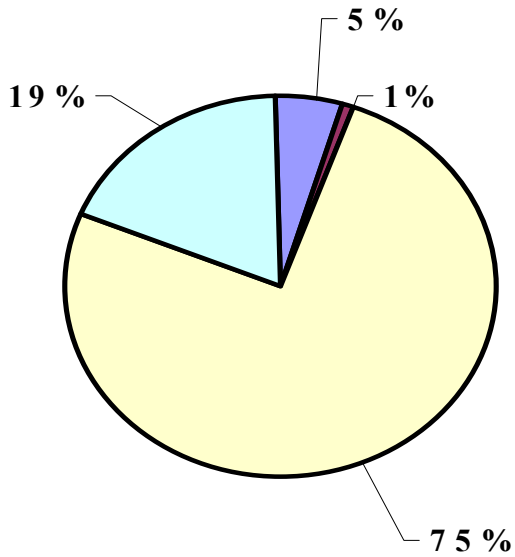
Source of Water



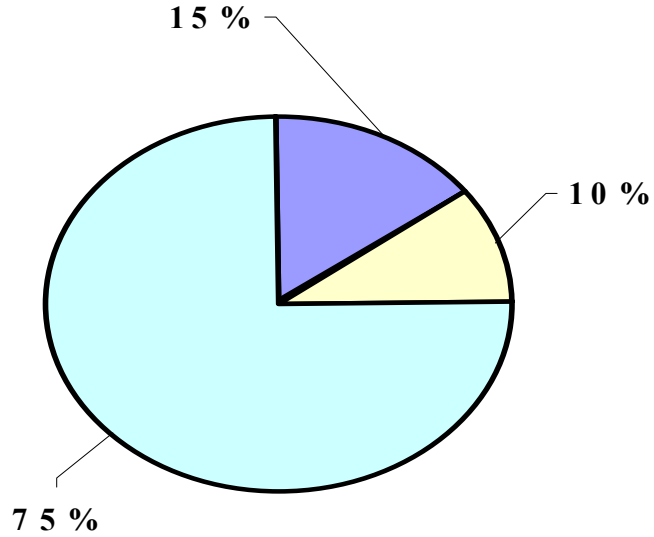
Surface Applications

Sprinkler Applications

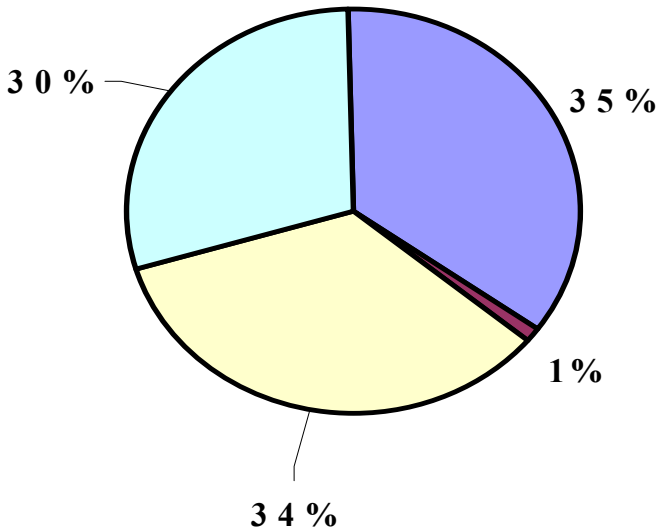
Colorado, Percent by Acres



Kansas, Percent of Acres

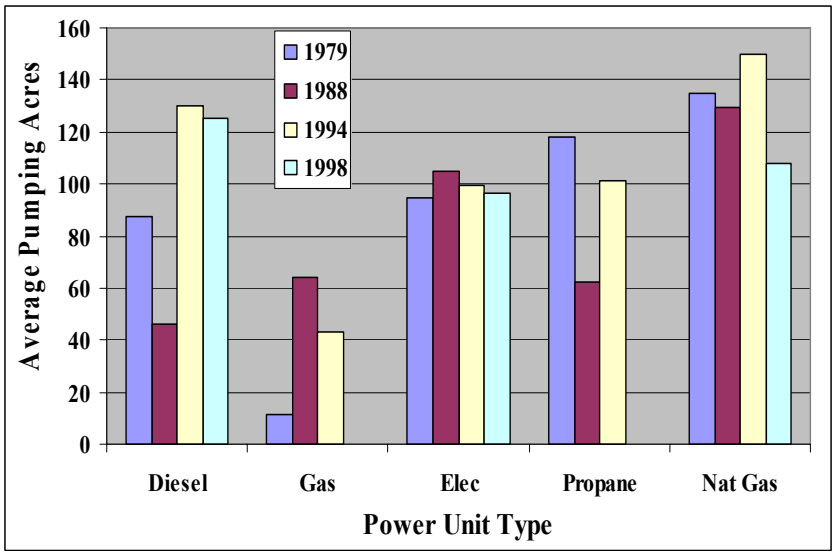


Texas, Percent by Acres

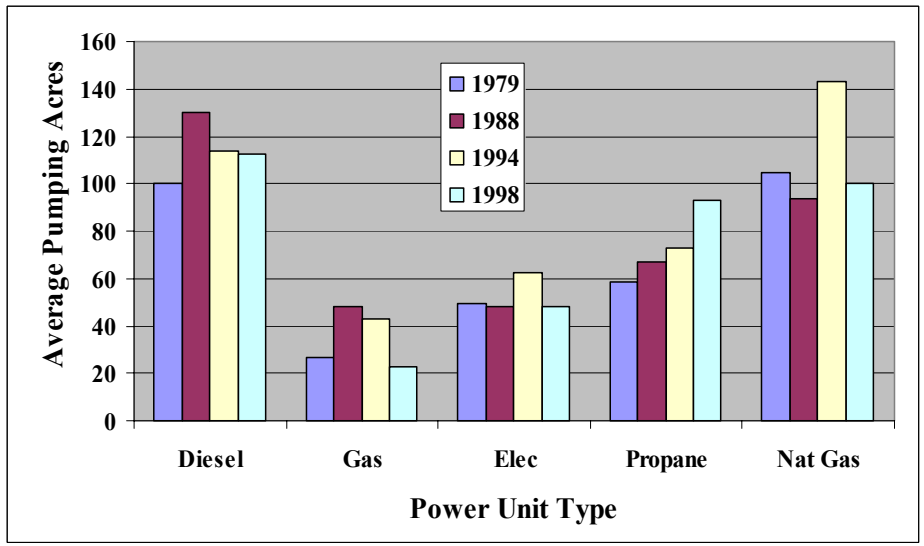


Diesel Gasoline Electric LP or Natural Gas

Colorado

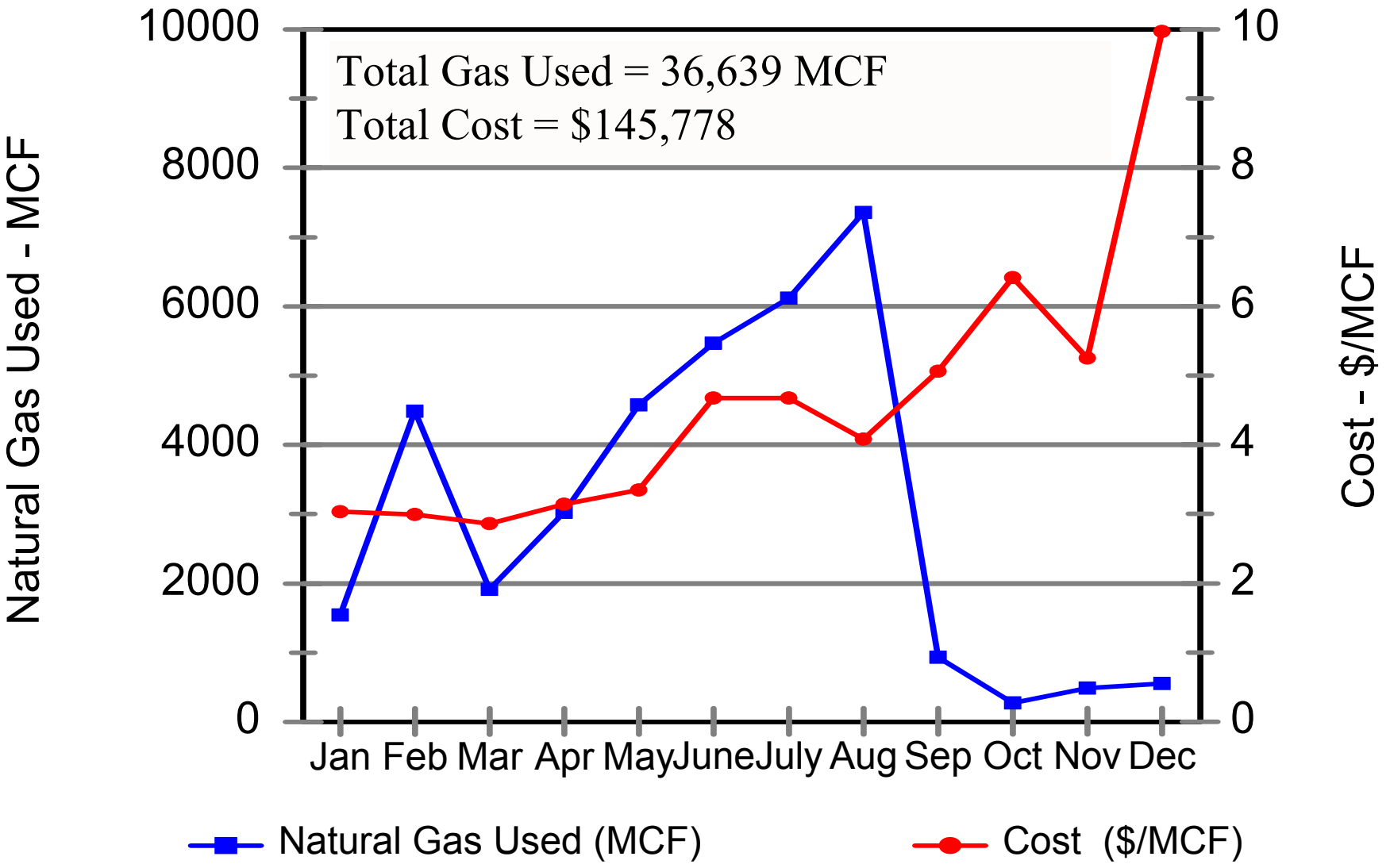


Texas

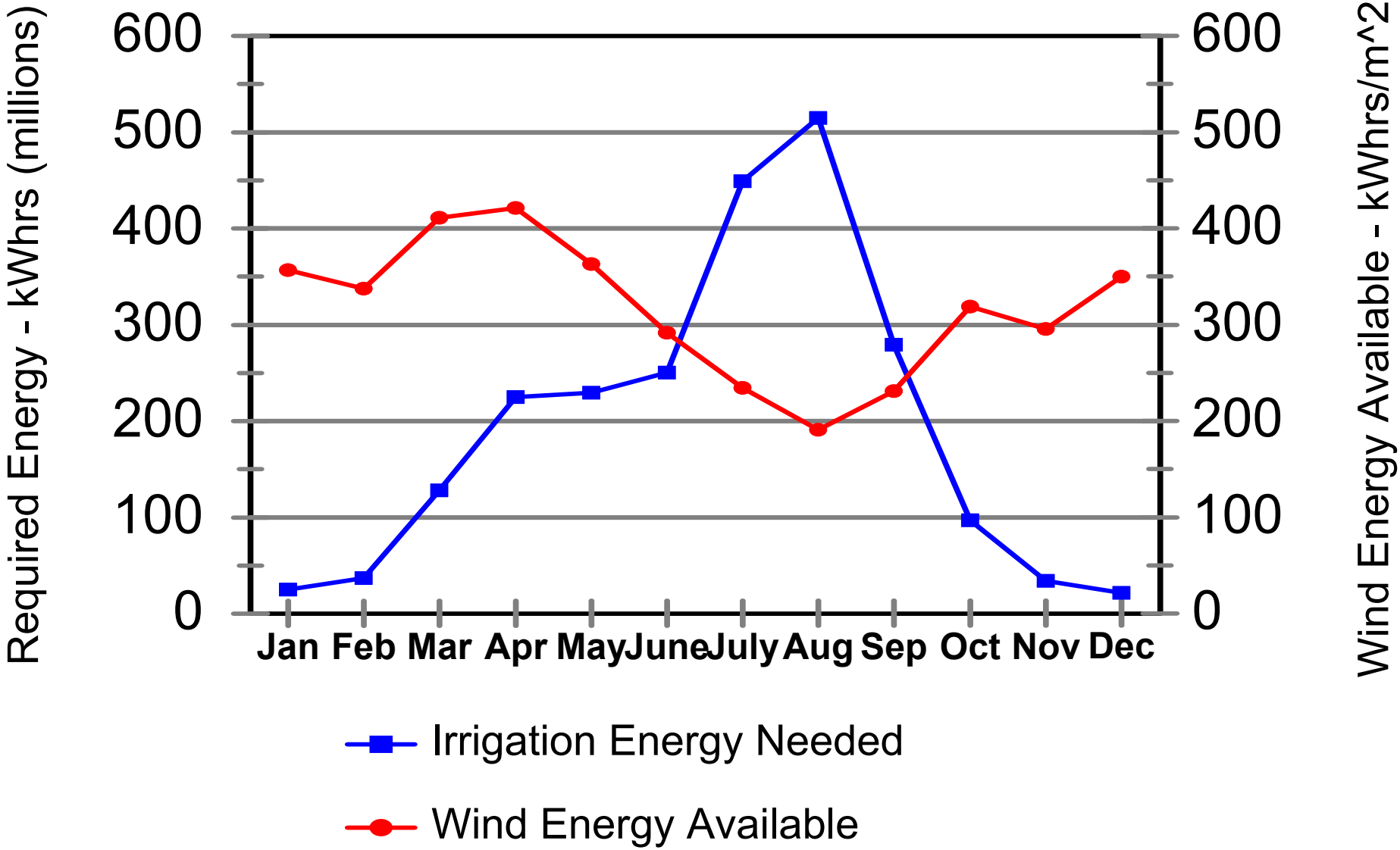


Natural Gas used for Irrigation (2000)

Typical Farmer - North Texas Plains



Irrigation Energy Needed & Wind Energy Available (1997-2000)



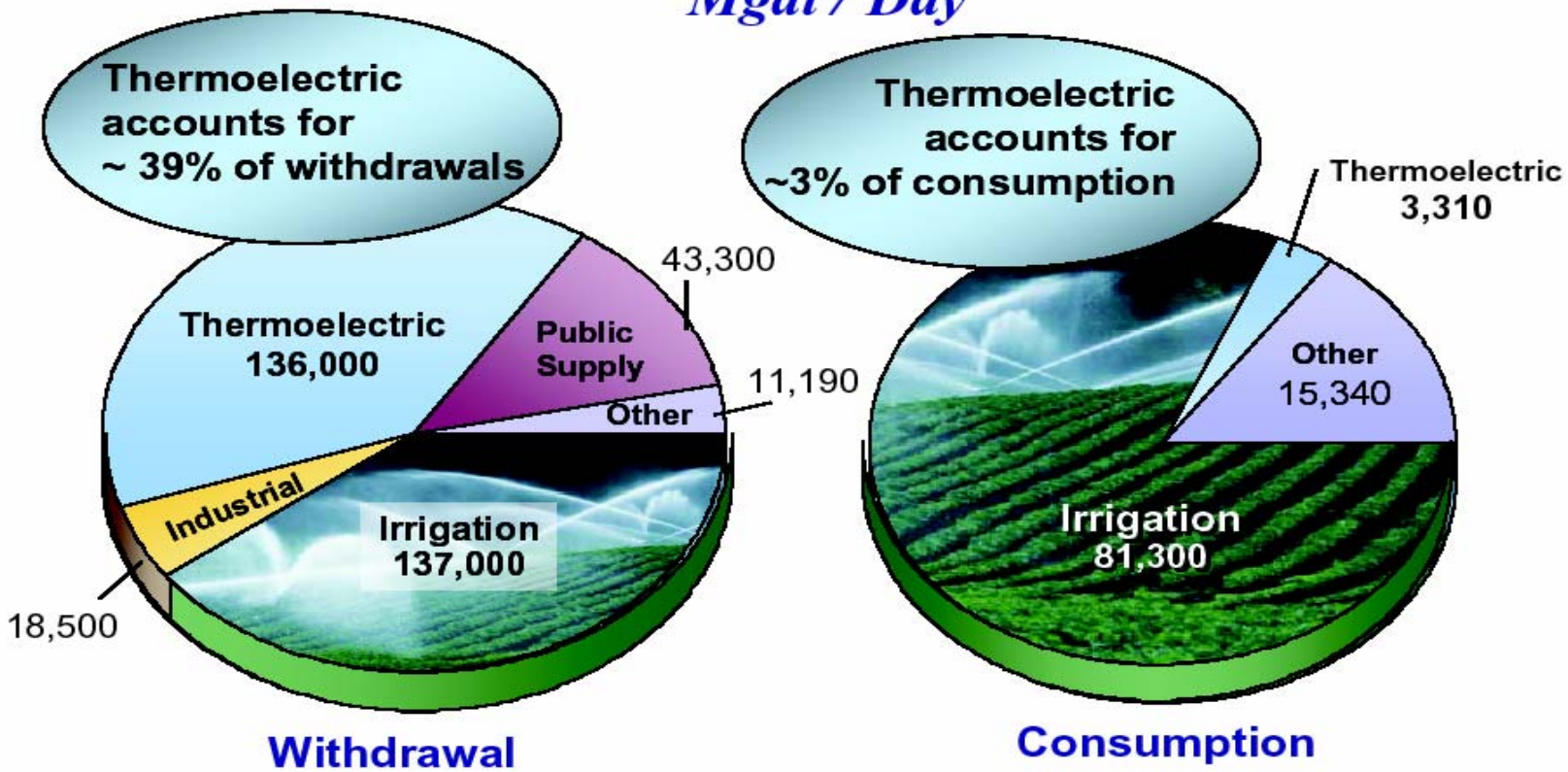
WESTERN RESOURCE
ADVOCATES

Water/Electricity Use at Fossil Fuel Power Plants

Bart Miller, Water Program Director

Freshwater Withdrawals and Consumption

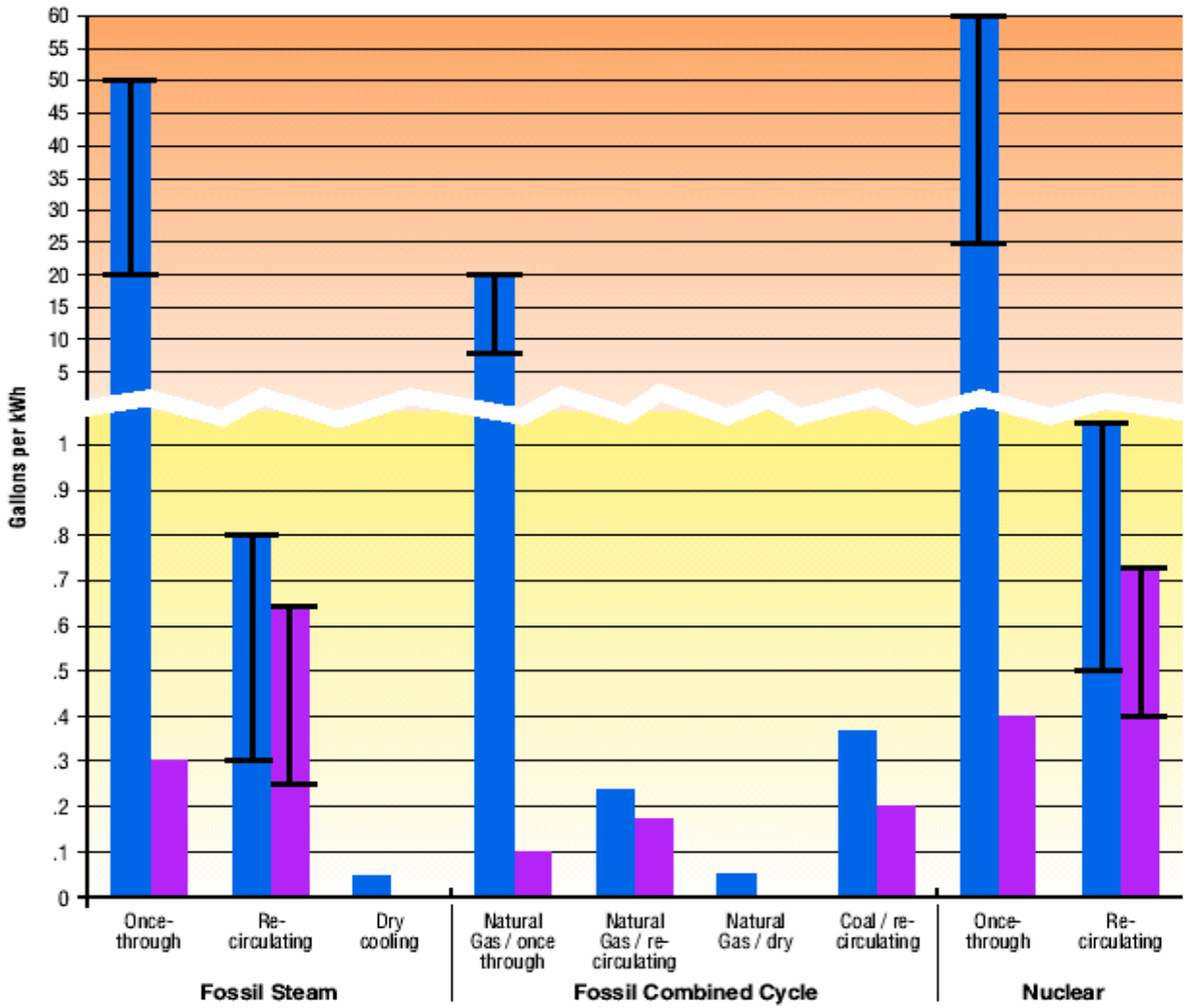
Mgal / Day



Ref.: "Estimated Use of Water in the United States in 1995," USGS Circular 1200, 1998
"Estimated Use of Water in the United States in 2000," USGS Circular 1268, March 2004

Thomas Feeley, III, "Responding to Emerging Power Plant-Water Issues – DOE/NETL's R&D Program"

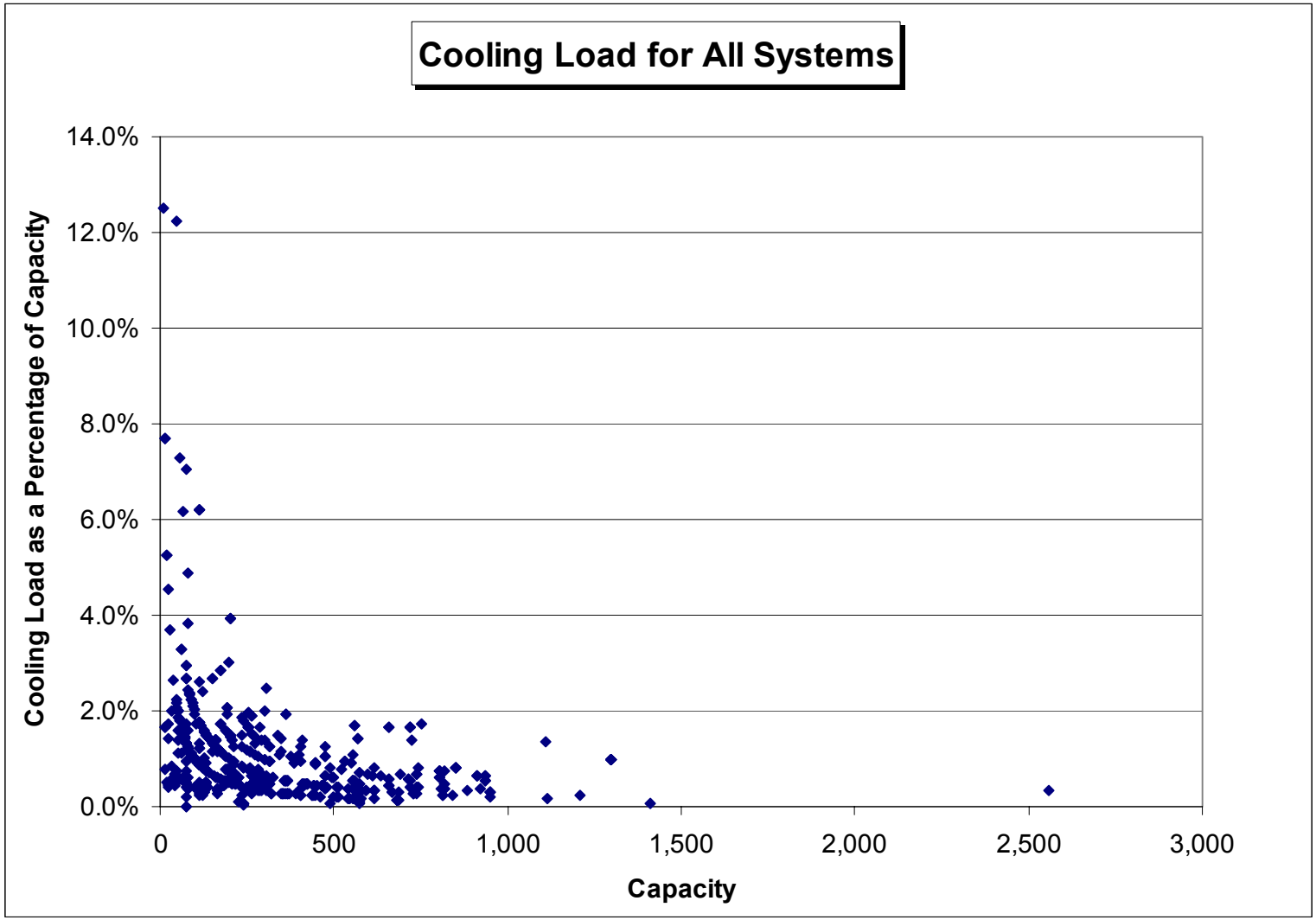
Cooling Water Withdrawal and Consumption, by fuel and technology in gal/kWh[a, b, c]



a Myhre, R. 2002. Water & Sustainability (Volume 3): U.S. Water Consumption for Power Production – The Next Half Century, EPRI, Palo Alto, CA: 1006786.

b EIA, 2002 and 2000. Form 767. Steam-Electric Plant Operation and Design Report. Schedule V. Cooling System Information. Section A. Annual Operations.

c Afonso, Rui. Dry- vs. Wet-Cooling Technologies, prepared for the Clean Air Task Force by Energy and Environmental Strategies, October, 2001.


Cooling Load for All Systems
Cooling Load as a Percentage of Capacity
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
0
500
1,000
1,500
2,000
2,500
3,000
Capacity

Growth in Power Demand

- Assume nationwide 272,000 MW net new generation for fossil fuel plants 2002-2025; 1.0% power to cooling; 70% capacity factor
- 2,720 MW * 8760 hrs/yr * 70%
- Result: 16.8 million MWH/yr to operate cooling systems at new plants
  - Would meet electricity needs of 1.4 homes

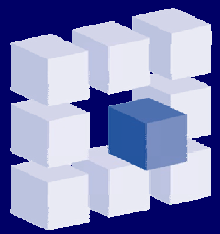
Situation Assessment

Energy Use

For

Pumping and Cleaning Water In The Production of Gas, Oil, Coal Bed Methane

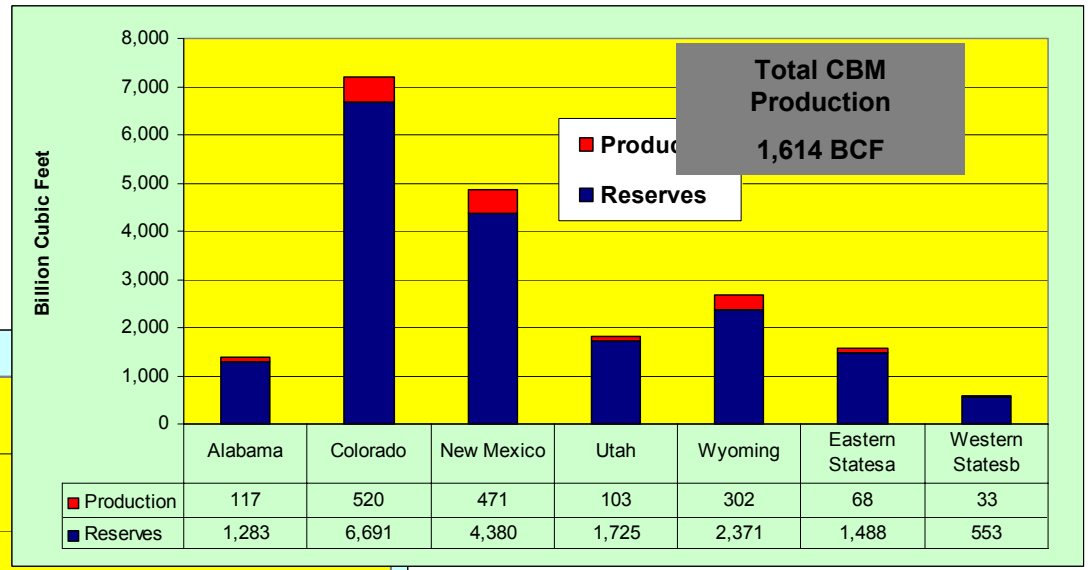
Prepared For
National Renewable Energy Laboratory
November 15, 2004



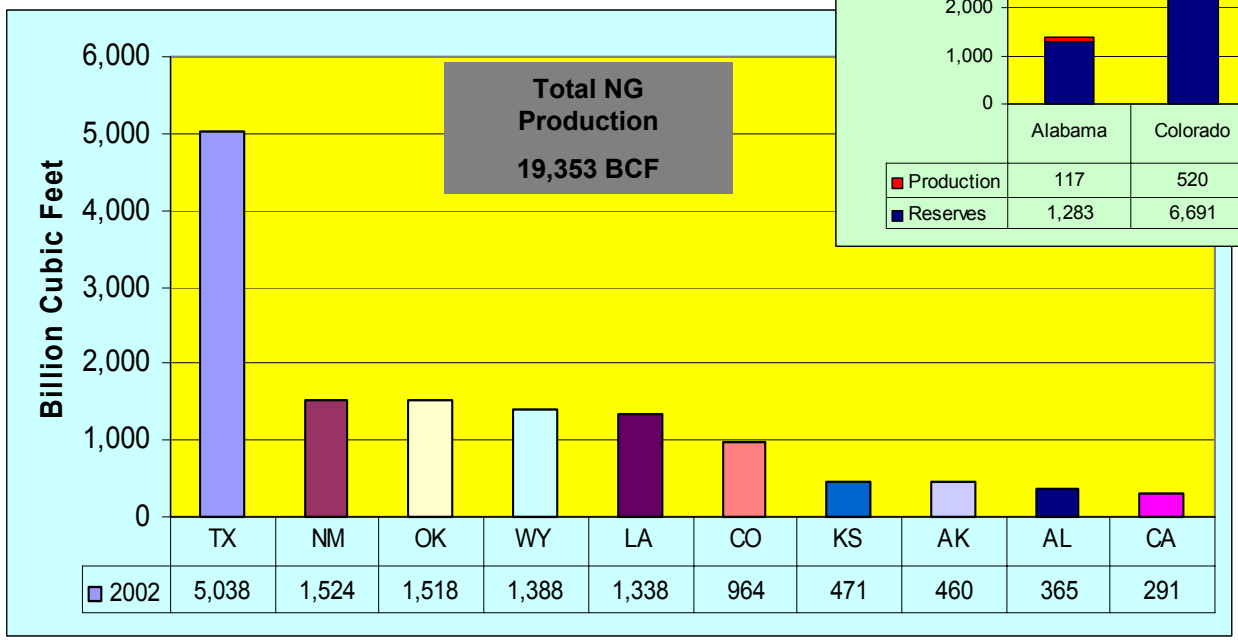
Robert Julian
Power Procurement Group
Belgrade, Montana
406-388-3300
Email: rjulian@ppgpower.com
Website: www.ppgpower.com

Natural Gas Production
Dry Gas and CBM
By State 2002

CBM Reserves / Production



Natural Gas Production



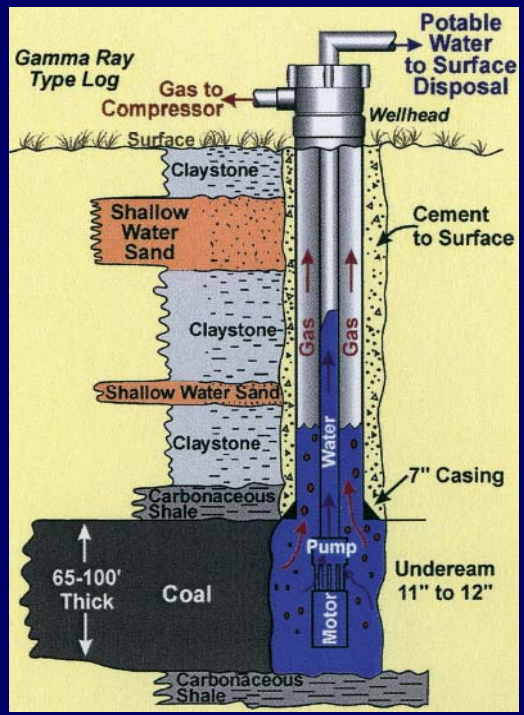
http://tonto.eia.doe.gov/dnav/ng/ng_sum_lsum_a_EPG0_PEU_DMcf_a.htm

CBM Water Production and Disposition

CBM Water Production

Disposal

- Injection
- Surface Discharge
- Surface Ponding



Reuse

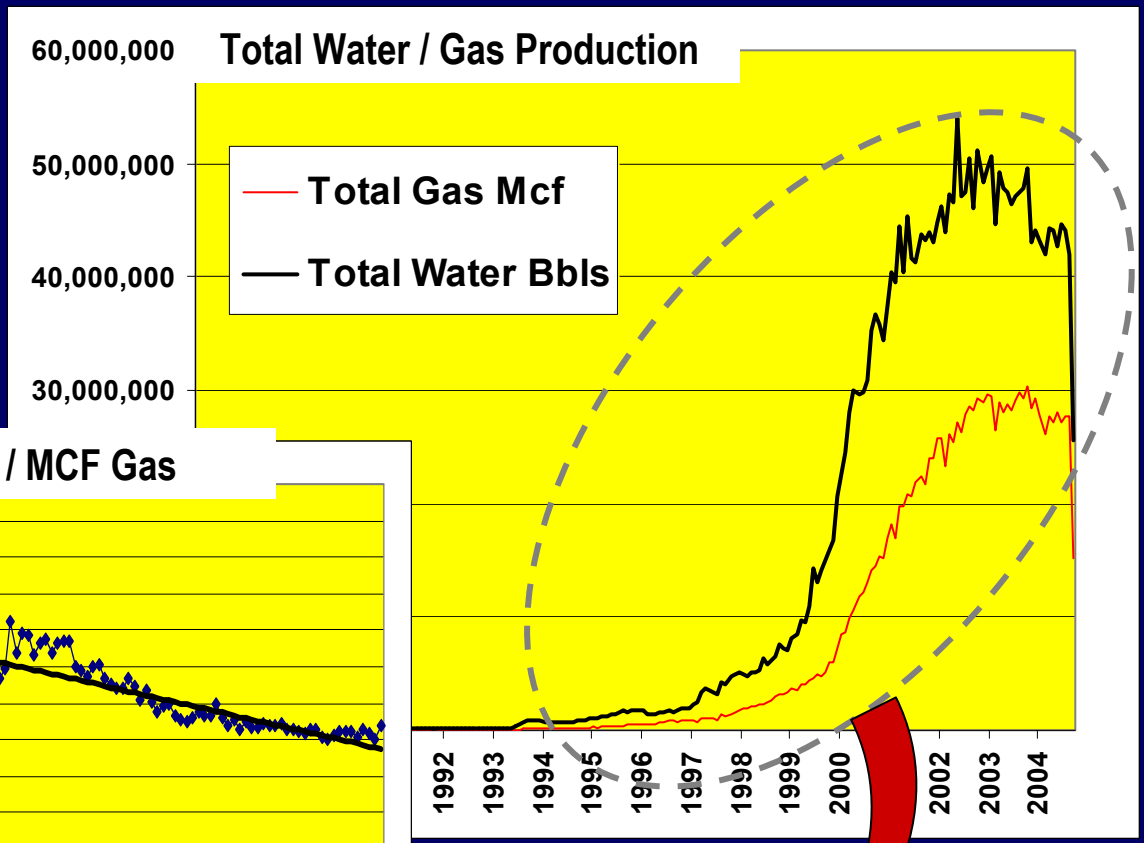
- Irrigation
- Stock Ponds
- Wetlands
- Water Supplies

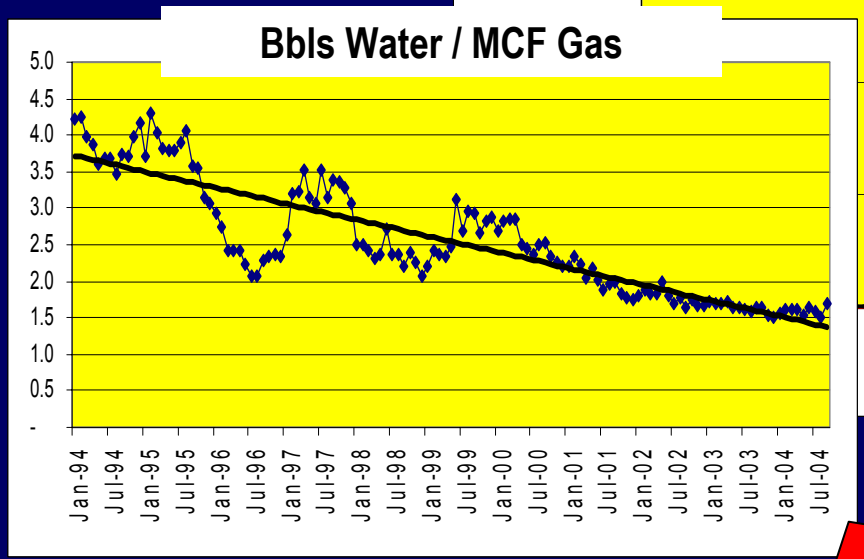
http://pubs.usgs.gov/fs/fs-0156-00/fs-0156-00.pdf

Wyoming CBM Water / Gas Production 1987 - 2004

Water Disposal Cost Varies Widely

- Conservative disposal costs = $0.01 - $.04/bbl
- High range disposal costs = $2.00/bbl
- Injection costs = $.20/bbl





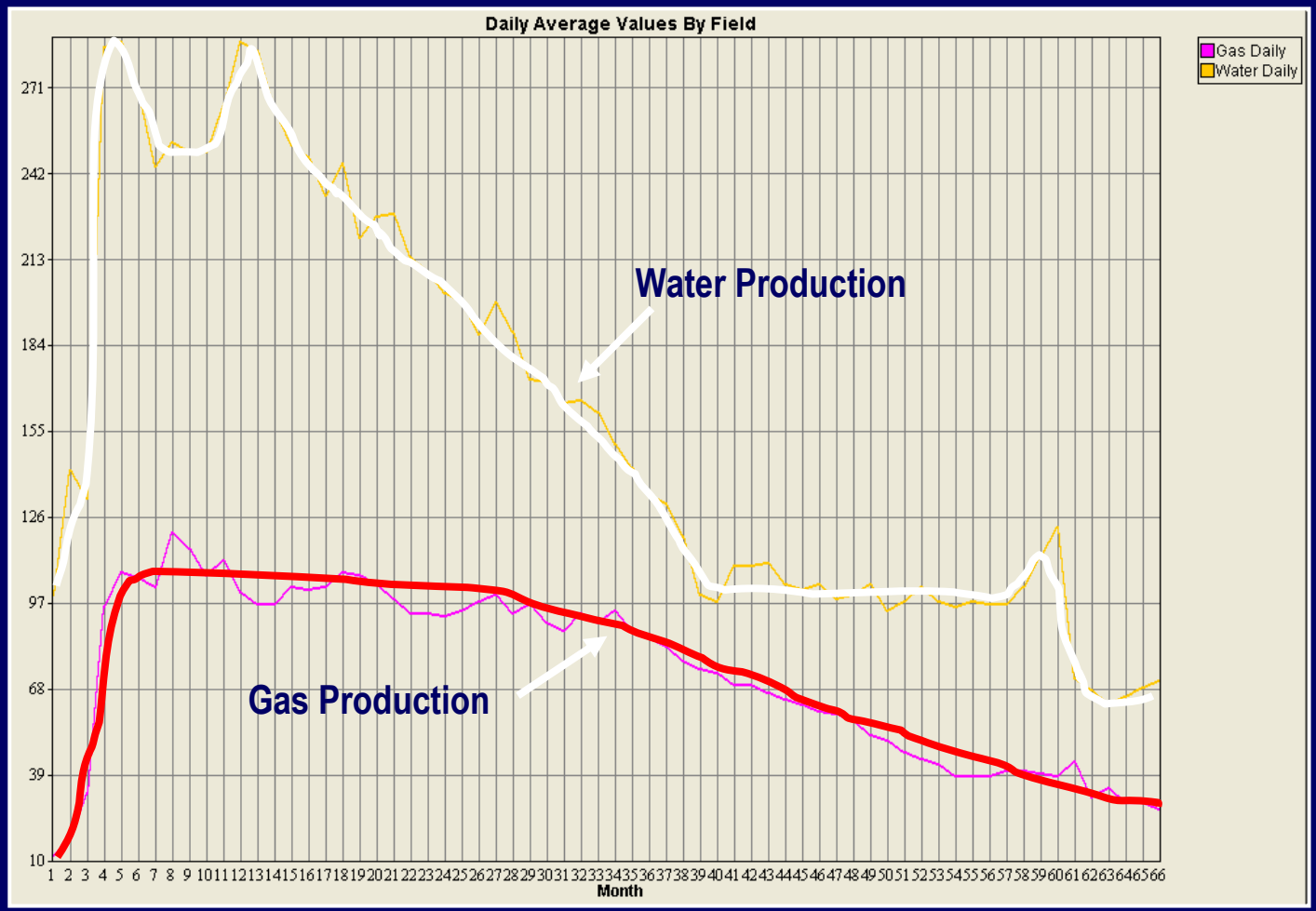
http://wogcc.state.wy.us/coalbedchart.cfm

CBM Water Production Example Fields - 2000

			Water Production	
Basin	State	# Wells	Bbl/day/well	Bbl/mcf
Black Warrier	**Alabama**	**2,917**	**58**	**0.55**
Powder River	**Wyoming**	**4,454**	**275**	**2.17**
Raton	**Colorado**	**459**	**266**	**1.34**
San Juan	**CO/NM**	**3,089**	**25**	**0.031**
Unita	**Utah**	**393**	**215**	**0.42**

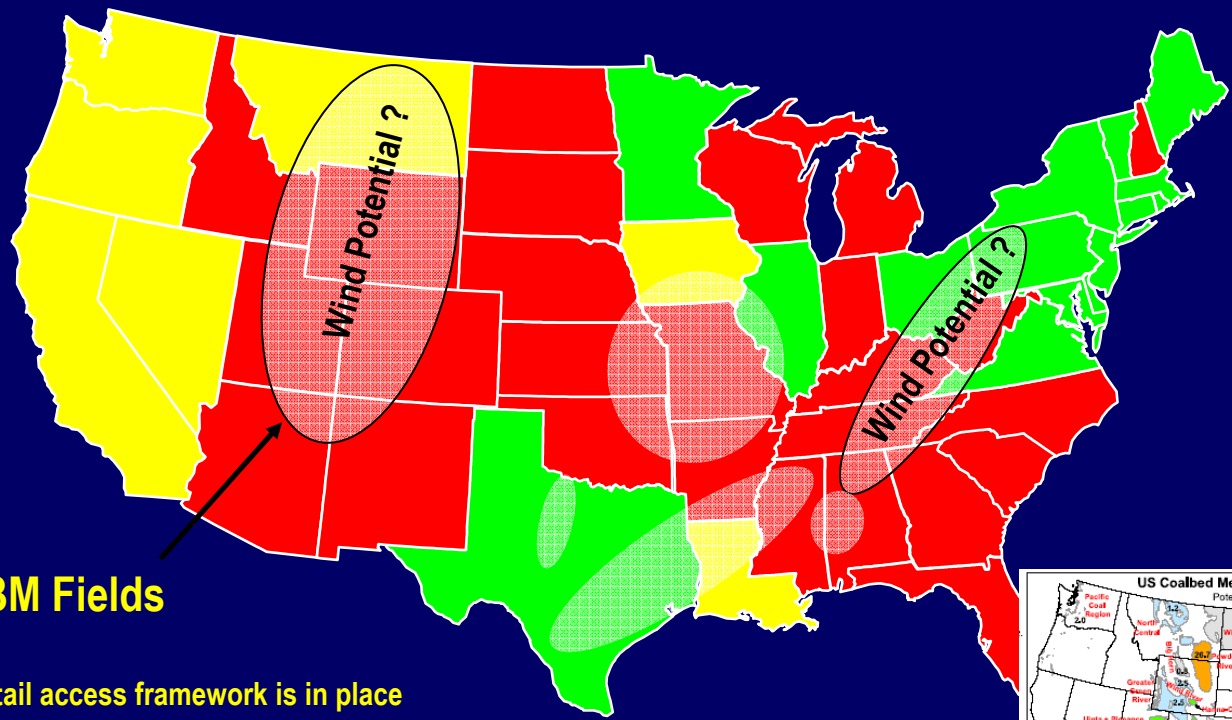
http://pubs.usgs.gov/fs/fs-0156-00/fs-0156-00.pdf

Typical CBM Water / Gas Production Curve



Montana Board Of Oil and Gas: Power River Basin CX Field

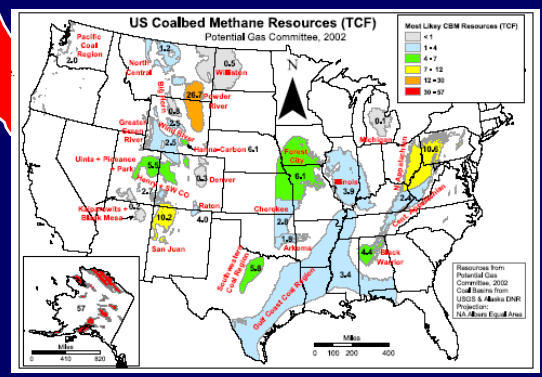
Key CBM Resource Areas
Electric Restructuring
And, Wind Generation Potential



Retail access framework is in place

Study is underway or legislation pending

No substantive activity or no decision

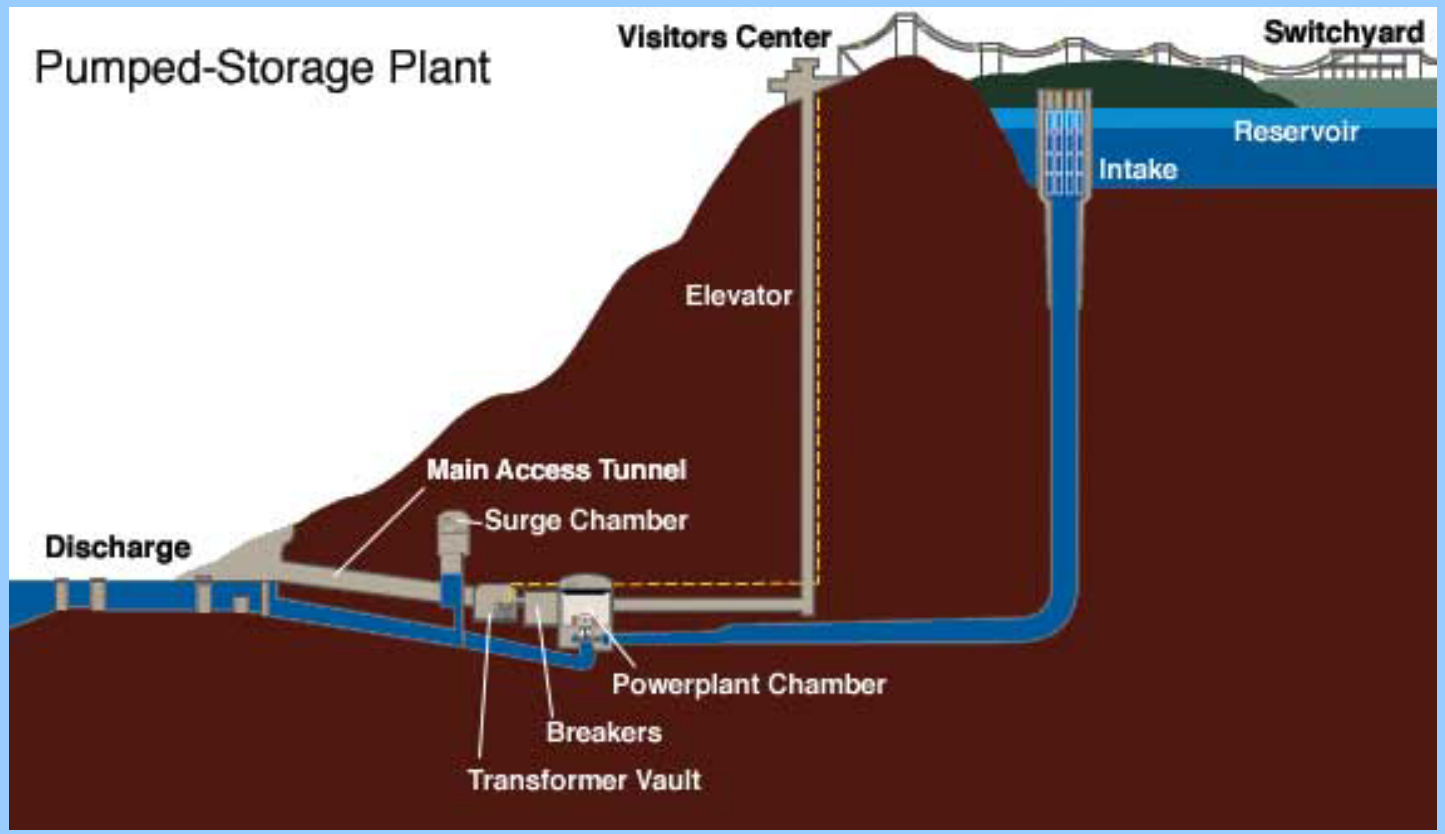


Source: Regulatory Research Associates Updated: November 2004 & EIA

Pumped Storage

Situational Analysis

Fundamentals of Pumped Storage



BASICS

- NO WATER CONSUMPTION
- EFFICIENCY 75 % TO 85 %
- ABOUT 20,000 MW INSTALLED CAPACITY
- THIS IS 2.5 % OF TOTAL INSTALLED
- UTILIZATION FACTOR 6% TO 25%
- NOW STORE ABOUT 3 TIMES ANNUAL WIND ENERGY

MORE BASICS

- ENRGY STORED IS REPDOMINANTLY COAL AND NUCLEAR
- FORTY PROJECTS IN THE US
- GOVERNMENT PARTICIPATION IN 20 PROJECTS
- SEVEN PROJECTS OVER 1,000 MW
- HIGH HEAD – CLOSE COUPLING PREFERRED
- LARGE RANGE IN HEAD, 73 FT TO 1700 FT
- LARGE RANGE IN CAPACITY, 4 MW TO 2,100 MW
- LARGE RANGE IN STORAGE CAPACITY

ENERGY COST

- FERC Form 1 data
- Marginal costs for sources

  $15/MWH to $25/MWH
- Actual Sales not reported
- Reported Pump Up Costs, $14 to $21/MWH

Basic Alternative to Pumped Storage

- Combustion Turbines
  - Low capital cost
  - Fuel Cost is largest cost component
  - Relatively easy to site
  - Short time frame
- Pumped Storage
  - High capital cost
  - Long lead time
  - Low energy cost
  - Multiple Benefits to Grid

The Energy-Water Nexus and the Municipal Sector

Robert Wilkinson, Ph.D.

Director, Water Policy Program
Bren School of Environmental Science and Management
University of California, Santa Barbara

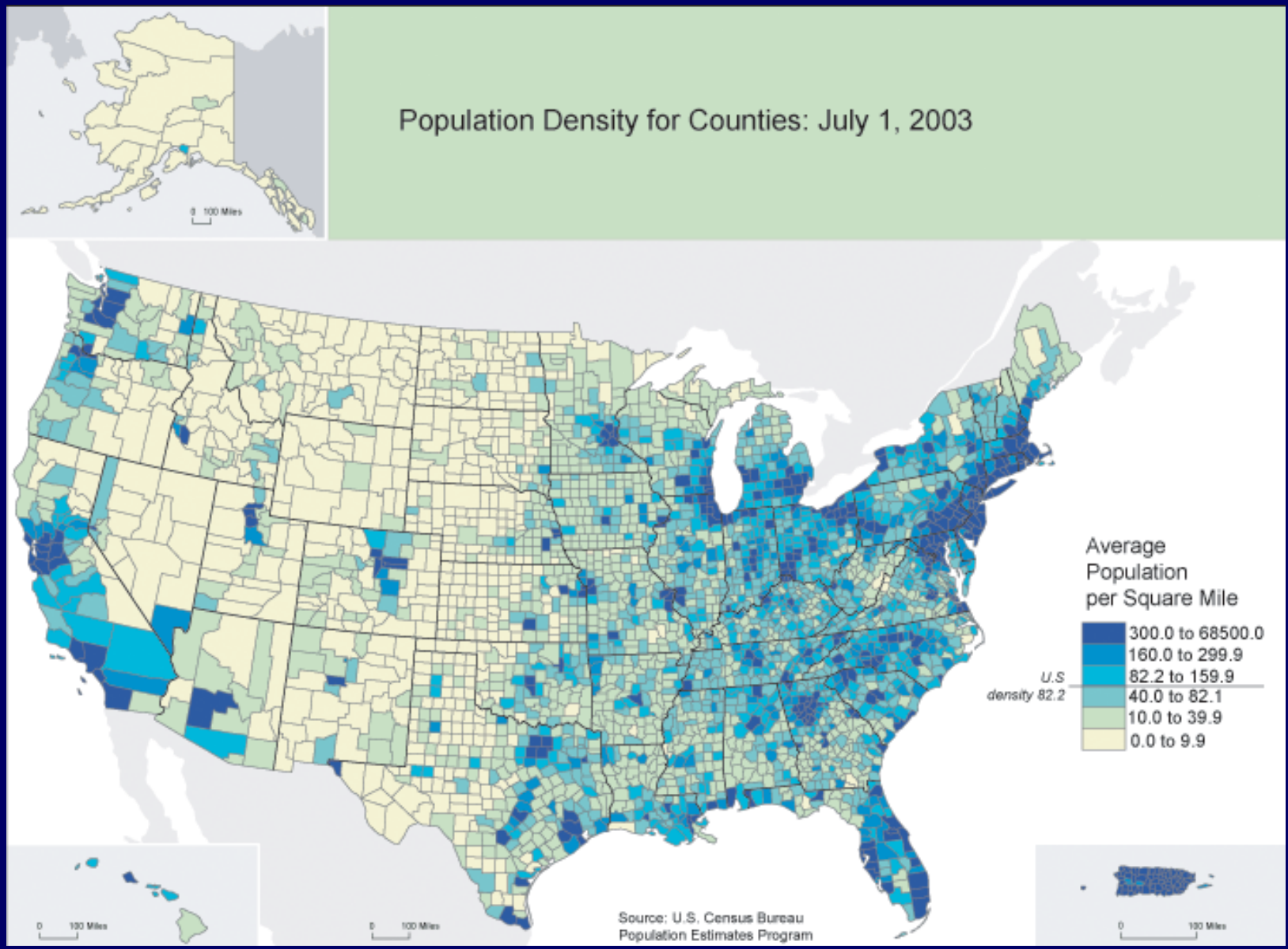
Population and Metropolitan Areas

According to 2000 US Census data, almost eighty percent of the US population currently lives in urban areas.

The trend is towards continuing growth of metropolitan areas across much of the country, and increasing demand on urban water supplies.

Federal Highway Administration website. Census 2000 Population Statistics, *US Population Living in Urban Versus Rural Areas*. Available at: http://www.fhwa.dot.gov/planning/census/cps2k.htm

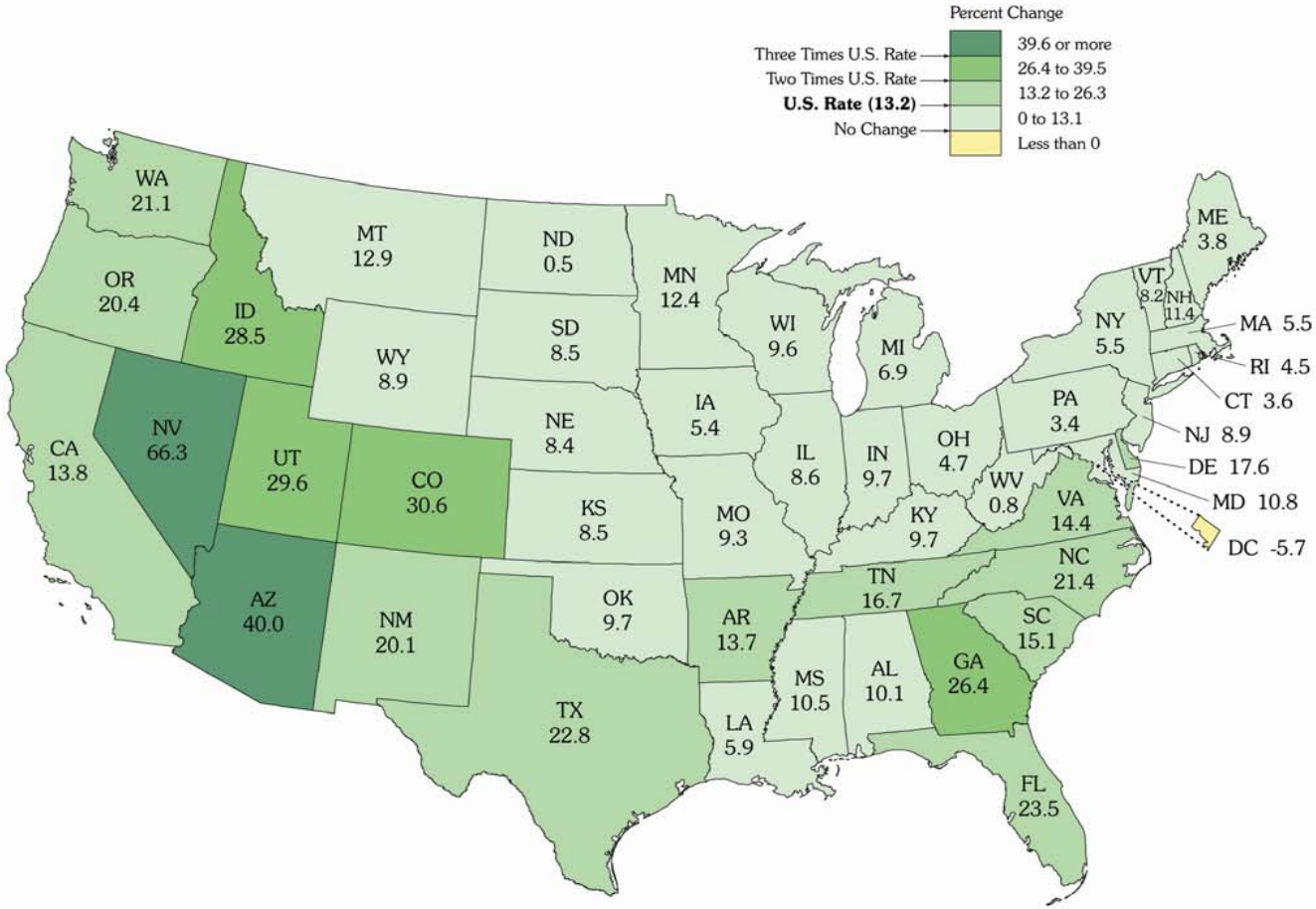
US Population Density by County, 2003



Source: US Department of Commerce, Economics and Statistics Administration, US Census Bureau http://www.census.gov/popest/gallery/maps/popden_c4.html

Demographic Changes: Population Has Grown Fastest in the West, Particularly in the "Public Land States"

Percent Change in Resident Population for the 50 States and the District of Columbia: 1990 to 2000



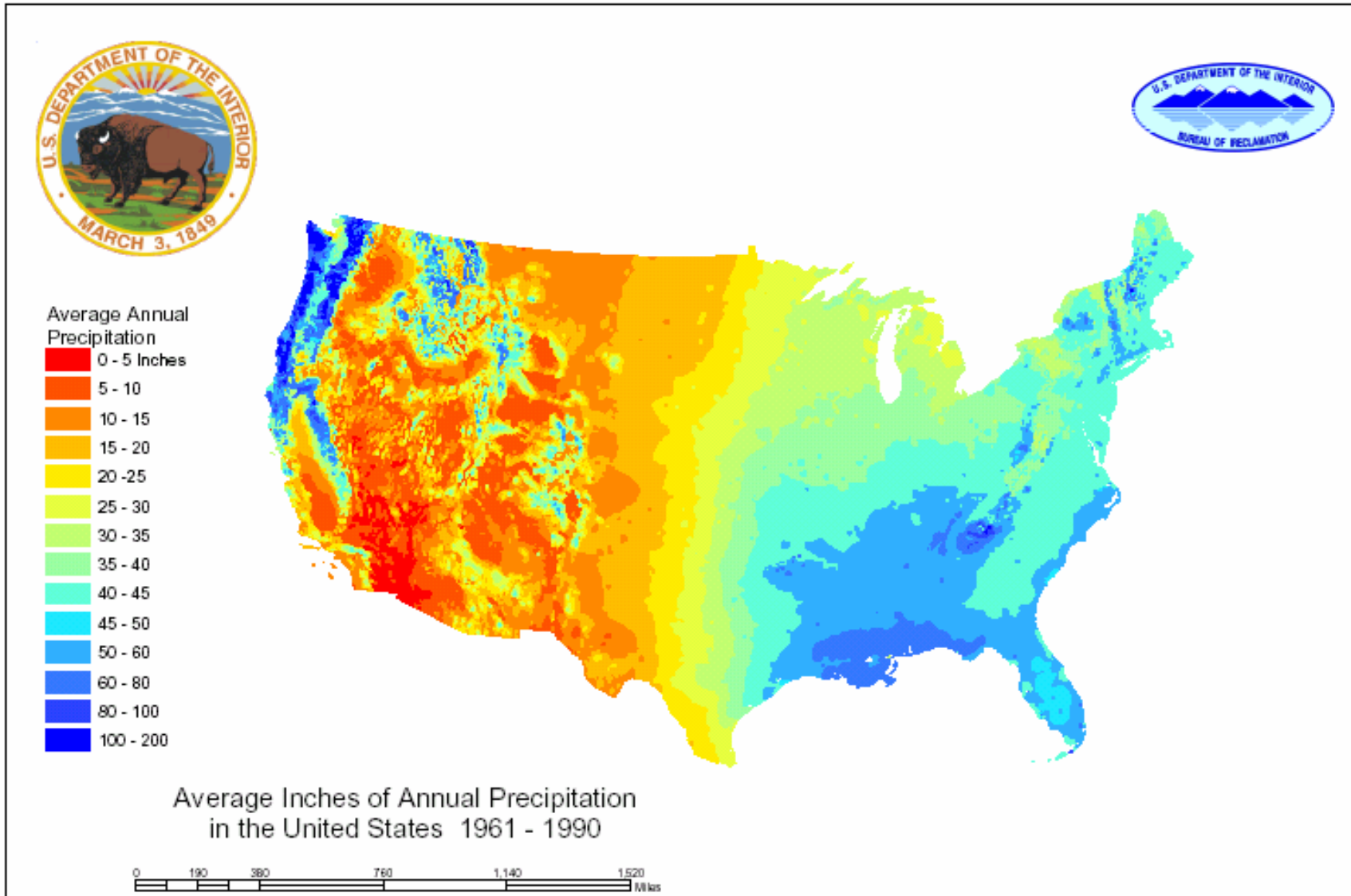
- Darker areas denote faster growth rates.

- Nevada (66%) and Arizona (40%) lead the nation.

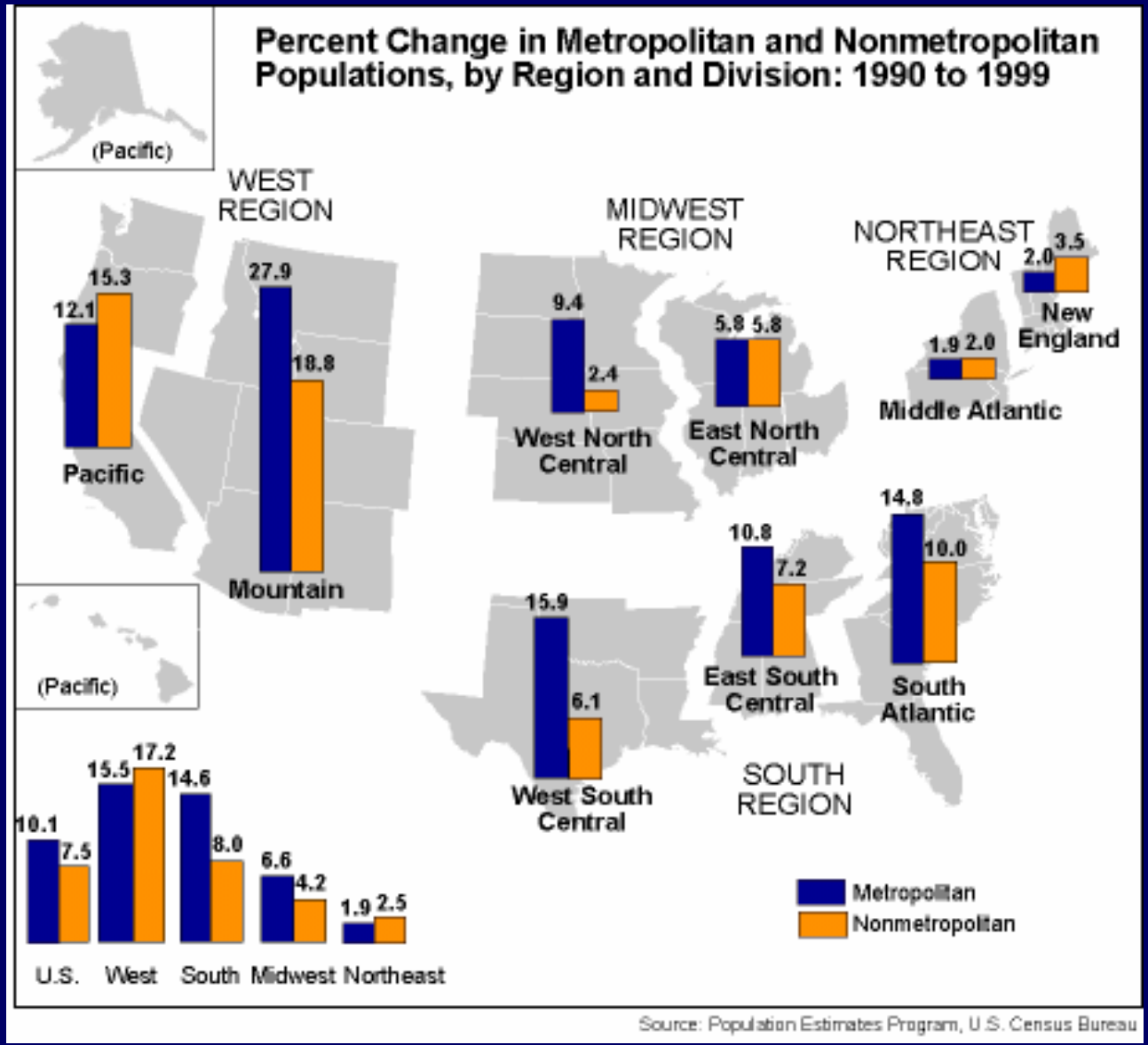
- Intermountain states average about 30%.

USCENSUSBUREAU
Helping You Make Informed Decisions

Average Precipitation 1961-1990

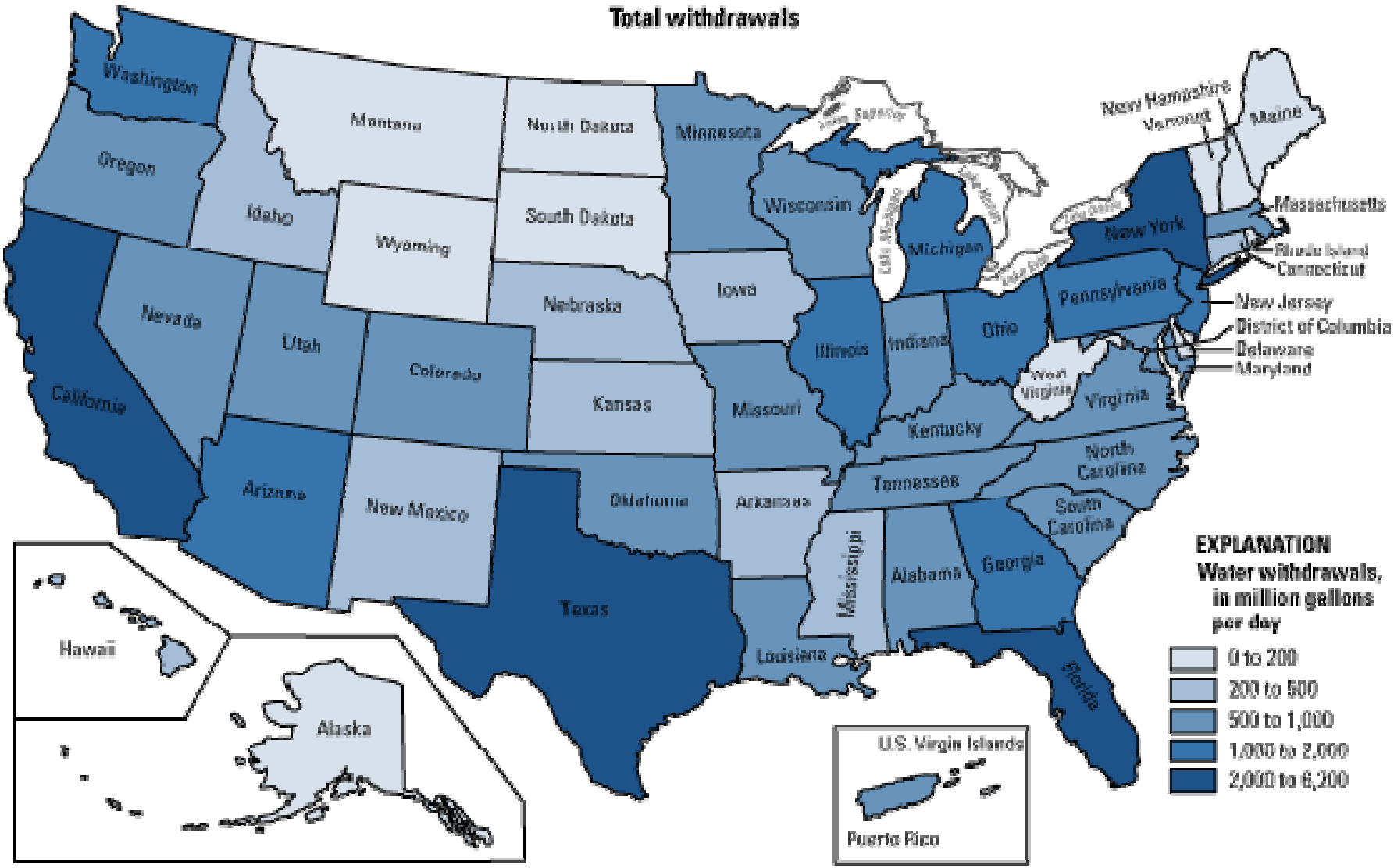


Percentage Change in Metropolitan and Non-Metropolitan Populations



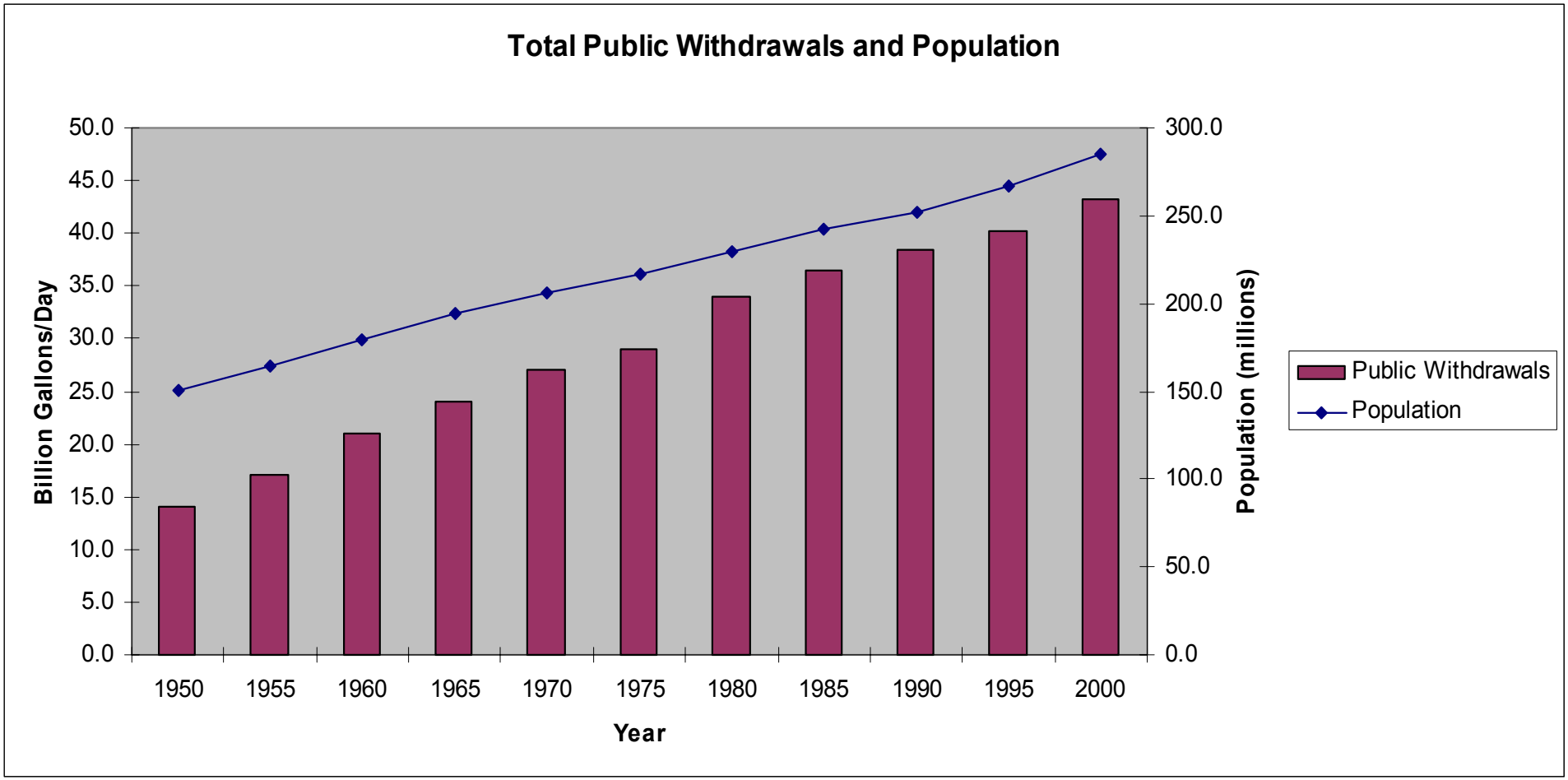
US Census Bureau website. *Percentage Change in Metropolitan and Nonmetropolitan Populations: 1990 to 1999*. Available at: http://www.census.gov/popest/archives/1990s/MA-99-map1.gif

Public Supply Withdrawals, 2000



http://water.usgs.gov/pubs/circ/2004/circ1268/htdocs/figure05.html

Total Public Withdrawals and Population



Source: **USGS Circular 1268,** released March 2004 and revised April and May 2004

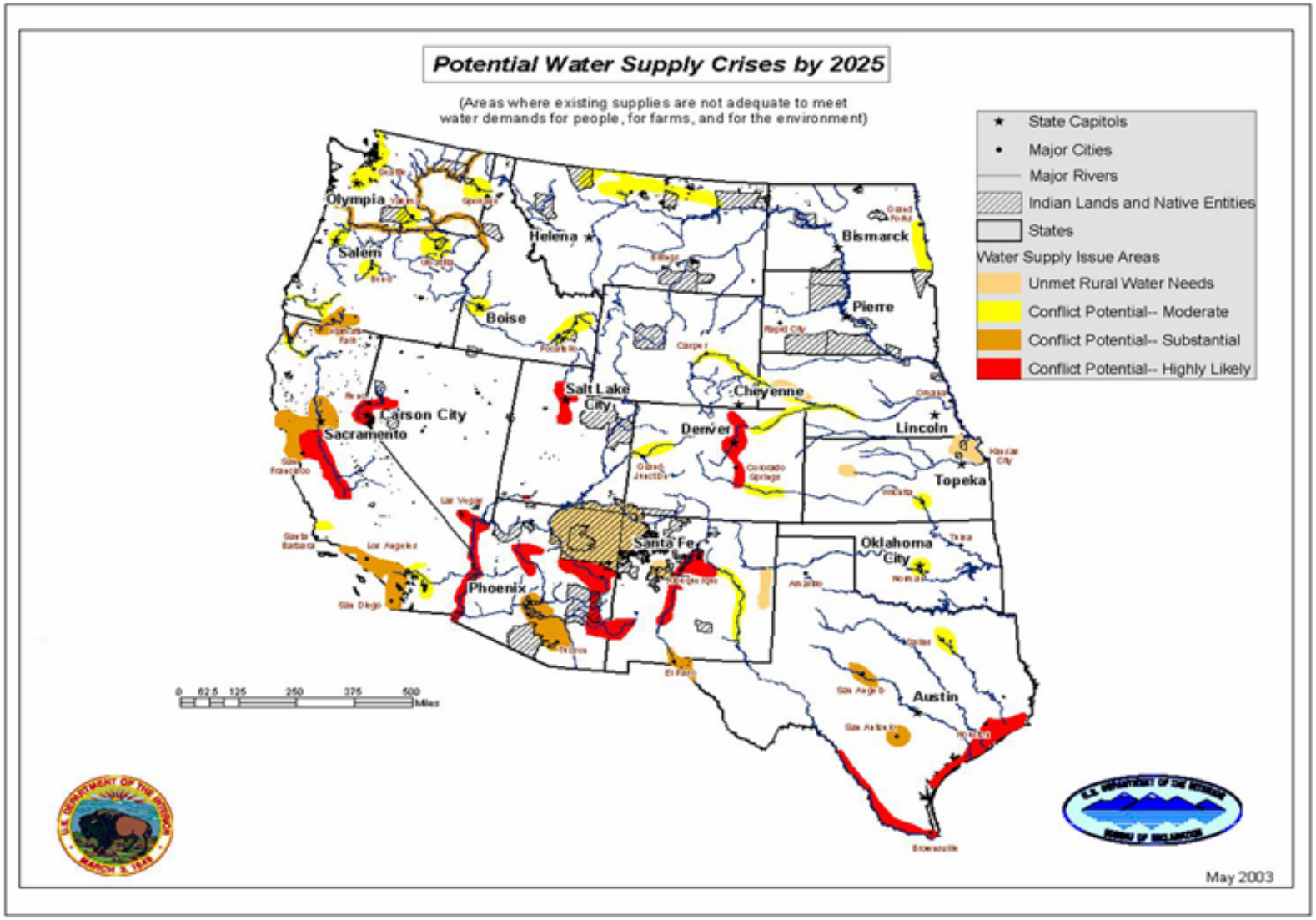
http://water.usgs.gov/pubs/circ/2004/circ1268/htdocs/table14.html

Energy for Pumping

The delivery of water in California accounts for one of the largest electricity energy uses in the state, currently estimated at about 7-8% of the state's overall usage.

An estimated national average figure is about 3%.

Hot Spots


Potential Water Supply Crises by 2025
(Areas where existing supplies are not adequate to meet water demands for people, for farms, and for the environment)
State Capitols
Major Cities
Major Rivers
Indian Lands and Native Entities
States
Water Supply Issue Areas
Unmet Rural Water Needs
Conflict Potential-- Moderate
Conflict Potential-- Substantial
Conflict Potential-- Highly Likely
Olympia
Salem
Helena
Bismarck
Boise
Pierre
Salt Lake City
Cheyenne
Carson City
Sacramento
Denver
Lincoln
Topeka
Santa Fe
Oklahoma City
Phoenix
Austin
0 62.5 125 250 375 500 Miles
May 2003

Water 2025: Five Realities

1. Explosive population growth in areas of the West where water is already scarce.
2. Water shortages occur frequently in the West.
3. Over-allocated watersheds can cause crisis and conflict.
4. Water facilities are aging.
5. Crisis management is not effective in dealing with water conflicts.

Drought Impacts

- Reduced water for thermal power production
- Increased demand by both urban and agricultural users
- Increased pumping requirements to meet demand (both surface and groundwater)
- Reduced hydropower production

US Population Distribution

	# of Areas	Total Population	Percent of US Population
Urbanized Areas over 200,000 population	153	166,215,889	58.274
Urbanized Areas 50,000 - 199,999 population	310	29,584,626	10.372
Urban Clusters 5,000 - 49,999 population	1838	25,438,275	8.918
Urban Clusters 2,500 - 4,999 population	1328	4,717,270	1.654
Total Urban Population		**225,956,060**	**79.218**

Federal Highway Administration website. Census 2000 Population Statistics, *US Population Living in Urban Versus Rural Areas*. Available at: http://www.fhwa.dot.gov/planning/census/cps2k.htm

DESALINATION and WIND ENERGY

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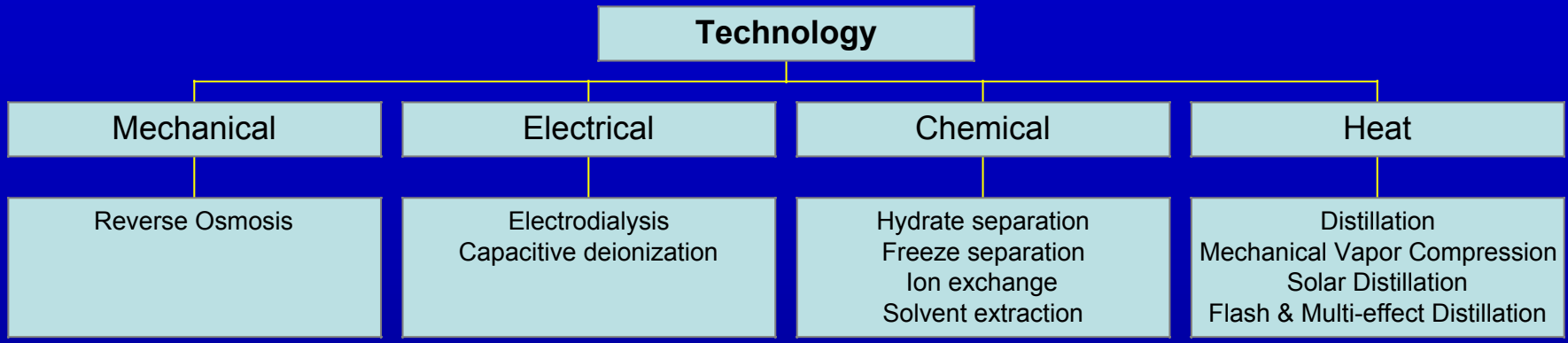
Abe Springer
Amanda Ormond
Tom Acker

Northern Arizona University and Ormond Consulting

WATER OVERVIEW

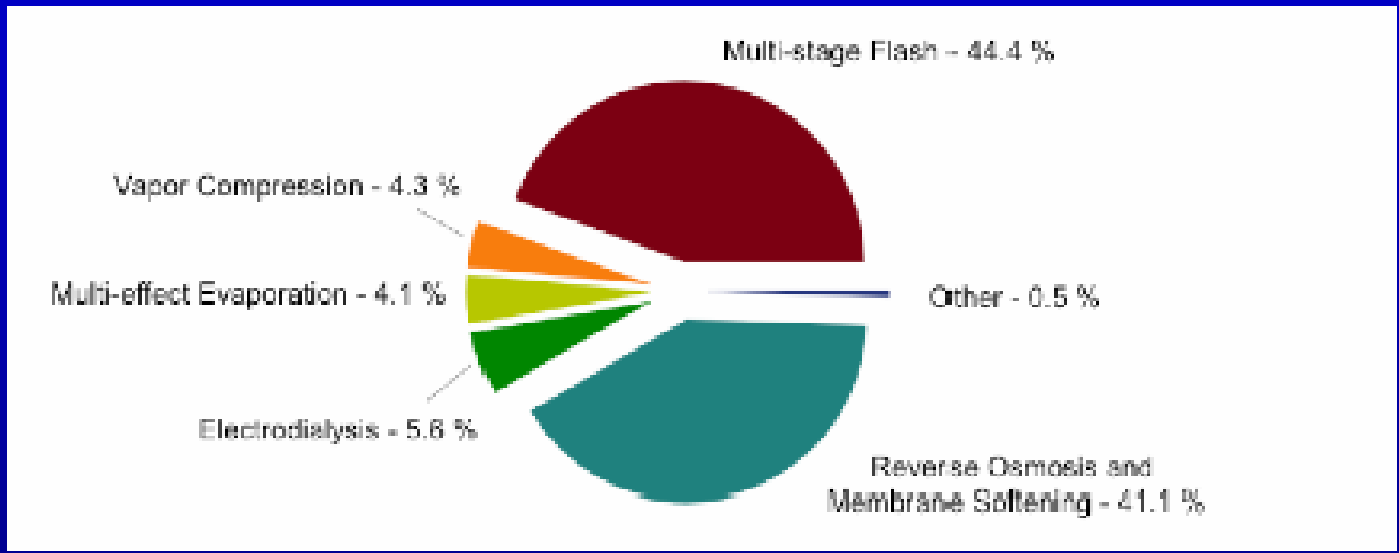
	World	US
Total water use (af/day)	8,700,000	1,250,000
Desalination capacity (af/day)	18,000	2,840
Specific use (af/person/year)	0.5	1.7

DESALINATION OVERVIEW



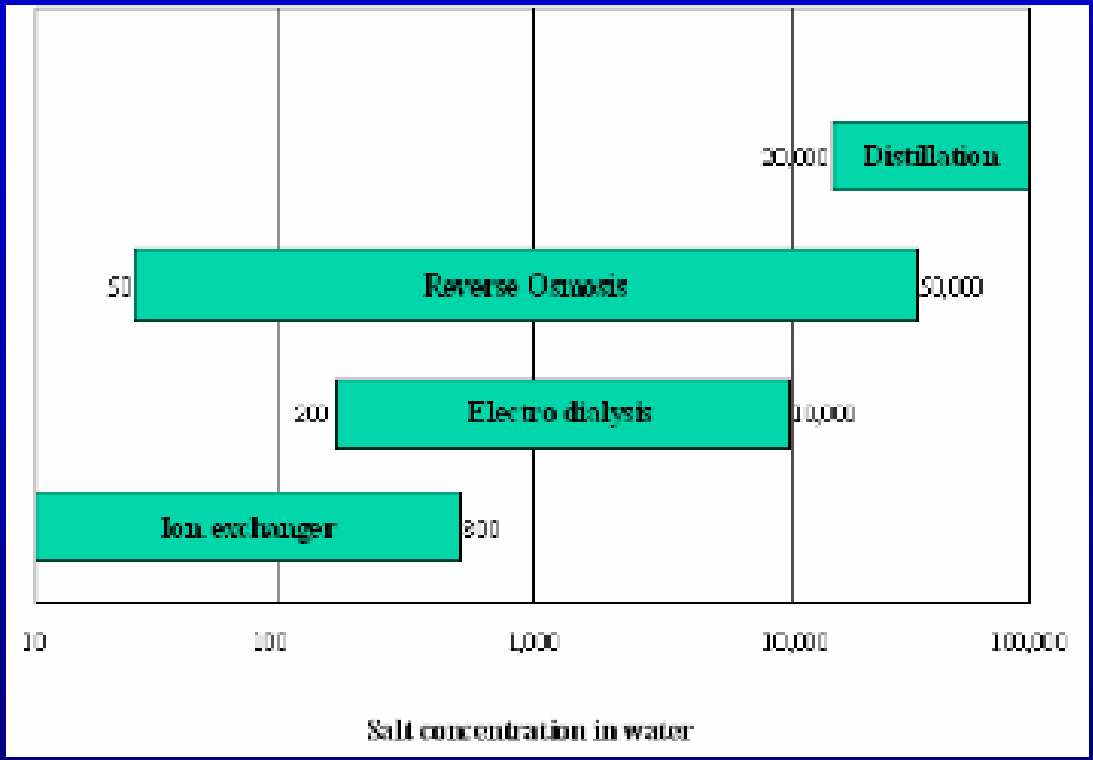
- Distillation practiced since ancient times
- ED since 1920s
- RO since 1950s
- Capacitive deionization not full-scale

INSTALLED CAPACITY



- Flash distillation & RO dominate
- MVC & ED minor players

APPLICATION DOMAINS



- Distillation & RO - seawater & brine
- ED & IX & RO - brackish water

GEOGRAPHIC DISTRIBUTION

World - 8,600 plants

Majority of facilities in Middle East (MSF)

US 20% of world plants

TX (100+ brackish plants) Sherman - 80af/day

FL (10+ plants) Tampa Bay - 77af/day??

CA (10+ plants) - 8.5 af/day (712af/day proposed)

WA, ID, MT, NC, NJ, HI, VA, CO, AZ

DESALINATION COSTS

- Cost is a function of saline content & plant size
- Electricity the major cost component (RO&ED)
- Fuel cost dominate for distillation processes
- Pretreatment cost vary with technology (RO~\$0.13/m^3)
- Cost of brine disposal should be considered
- Tampa Bay - 14MW installed (77 af/day desal)

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